June 1, 1937. J. C. BUERKE 2,082,479

TRAFFIC CONTROL

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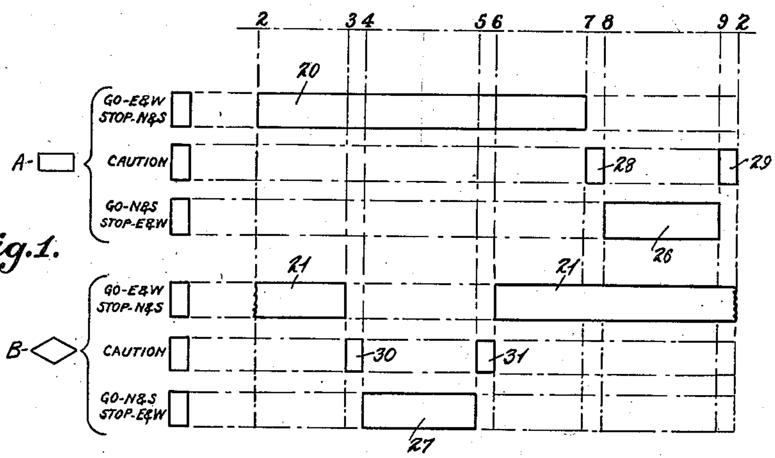

Fig.1.

Fig.2.

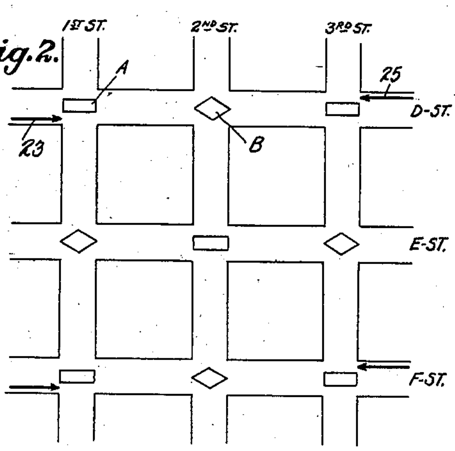

Fig.3.

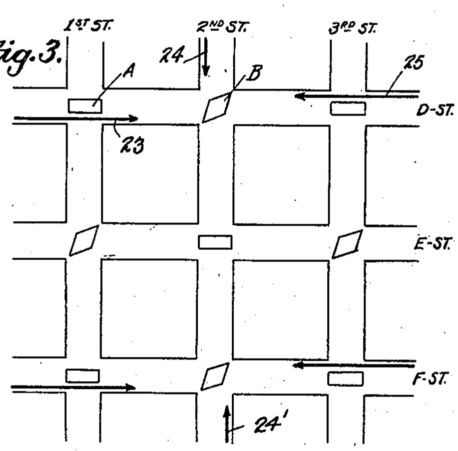

Fig.4.

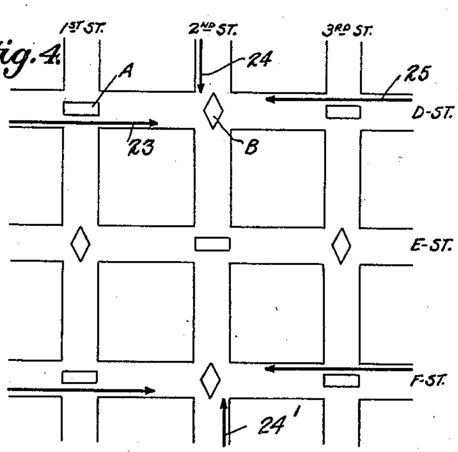

Fig.5.

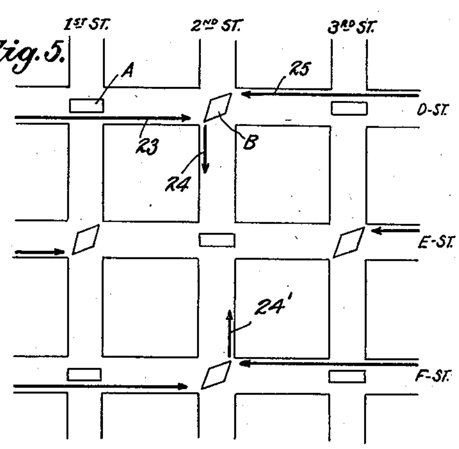

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Fig. 6.

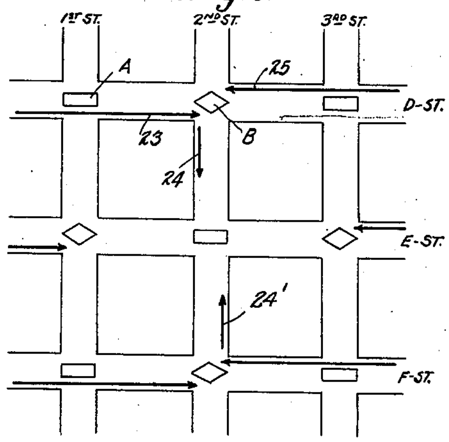


Fig. 7.

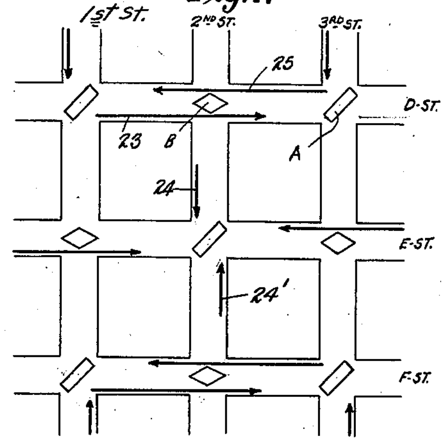


Fig. 8.

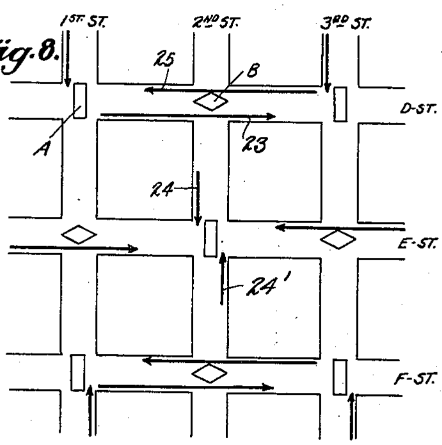


Fig. 9.

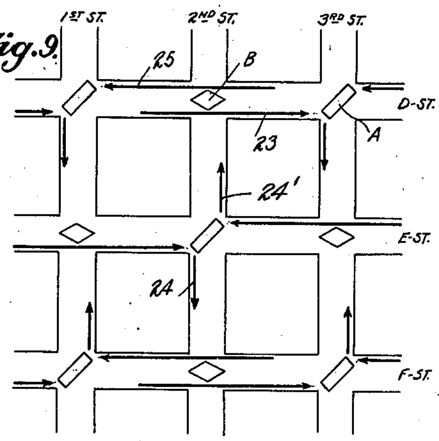


Fig. 10.

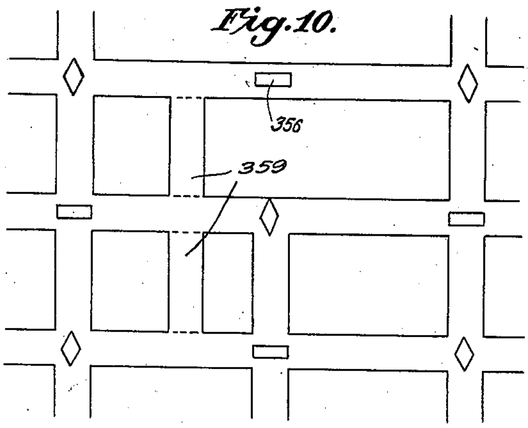
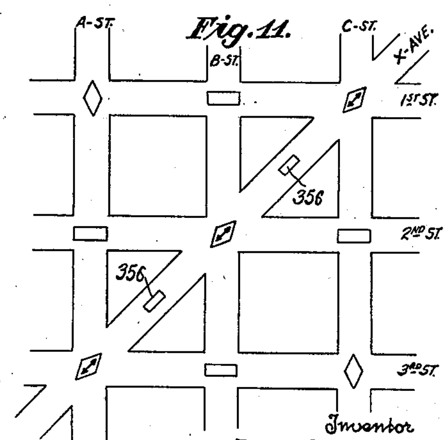


Fig. 11.



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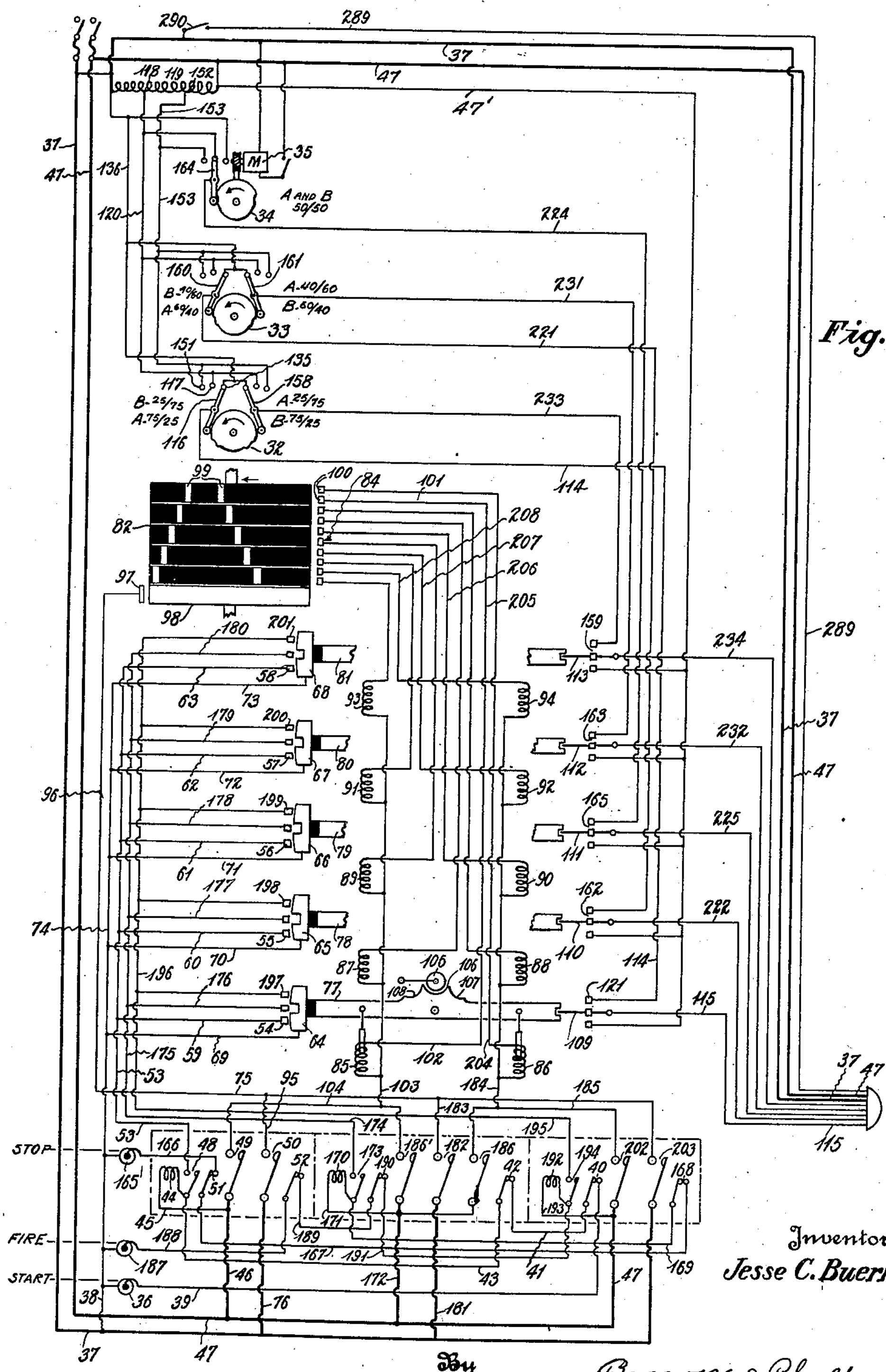

Fig. 12.

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Fig. 13.

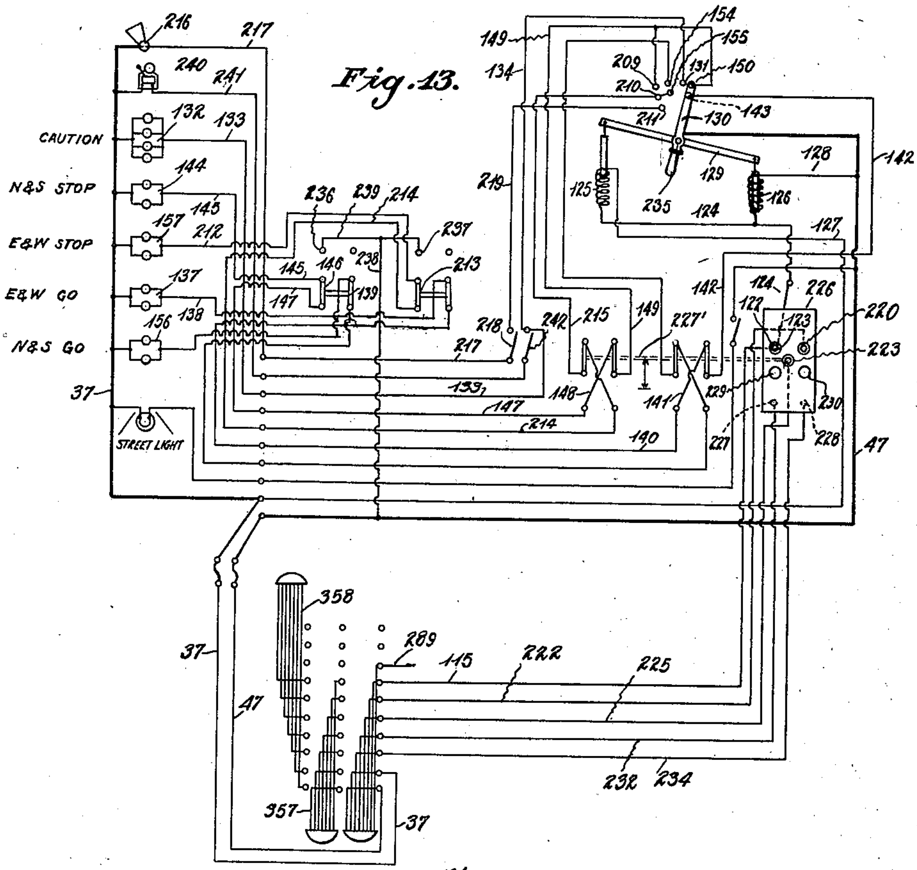

Fig. 14.

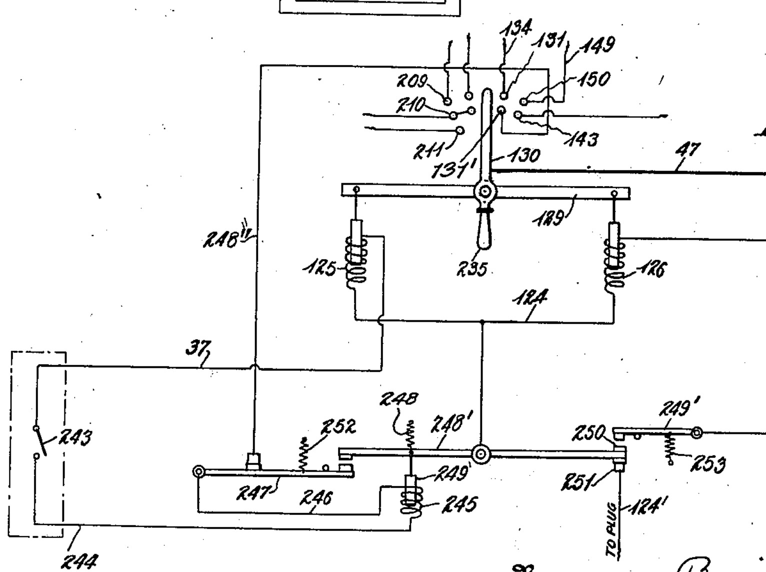

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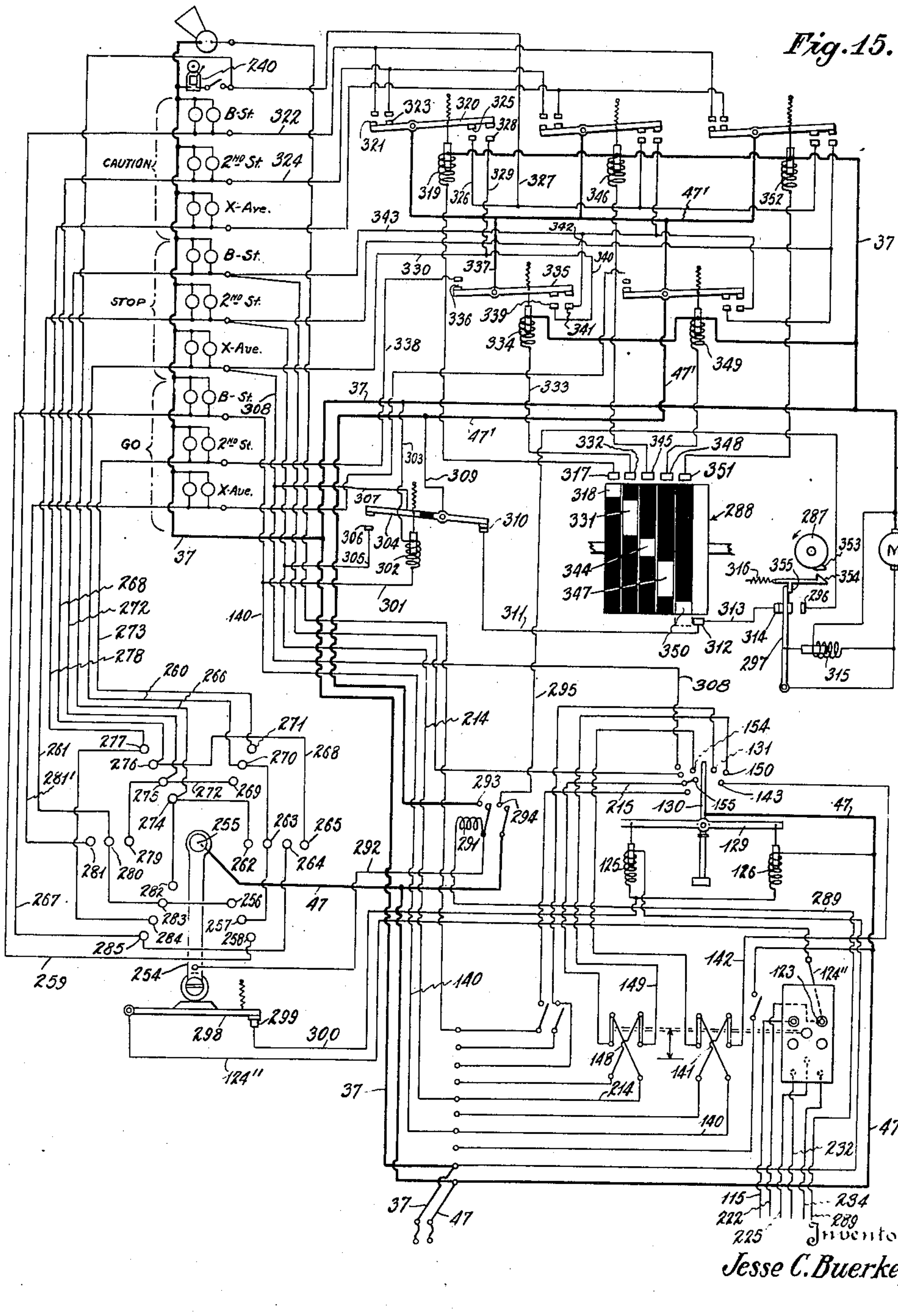
Fig. 15.



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Patented June 1, 1937

2,082,479

UNITED STATES PATENT OFFICE

2,082,479

TRAFFIC CONTROL

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Application September 15, 1928, Serial No. 306,119

22 Claims. (Cl. 177—337)

The invention relates to traffic control methods and systems for cities and towns.

In general, two types of such systems have gone into use. One such system is known as the "synchronous system" in which all north-south traffic throughout the area under common control will move at the same time while all east-west traffic is stopped and the reverse. An advantage of this system is that where traffic in one direction preponderates, this traffic may be given a greater proportion of moving time than that given the traffic of lesser volume.

The second system in use is that known as the progressive system in which the "go" lights in each street are alternated with the "stop" lights at consecutive intersections in such a manner that a vehicle driven at the proper speed may proceed the full length of a street without being halted by a signal turned against it. A disadvantage of the latter system has been that it has been necessary, so far as known to me, to operate the signals in the two directions on a fifty-fifty time proportion basis. That it is impossible to vary proportions from a fifty-fifty basis in a simple, alternated-color, progressive signal system is evident when considering that the signals in any direction of travel are of opposite color at the same instant at consecutive intersections, and if the larger portion of the time cycle is given to one direction of travel at one intersection, the cross travel at the next intersection is receiving the same large portion, and the through traffic will receive the remaining small portion of the cycle at the said next intersection.

Unlike the methods which attempt to offset this inflexibility of the "progressive system" by progressing waves of traffic in one general direction at the expense of the directly opposite traffic, (with more or less complicated means for generally reversing the progression), by adjusting the lag of the individual intersection control means in its cycle in conformity with the distance between successive signal stations, the traffic moving at a fixed speed in one direction, as exemplified in patent to Woodford, 1,659,904, Feb. 21, 1928, the present system maintains a fixed angle of like signals in the signal cycle between all signal stations to give equal consideration to traffic in directly opposite directions, and varies the speed of traffic in accordance with the lengths of the individual blocks, with compensating means for extra long or extra short blocks, and provides, selectively at any intersection, any desired proportion of "go" time between through and cross traffic at that intersection, and moves all traffic trains continuously in strict coordination by maintenance of definite relations between the mid-points of all trains. By the term "train" is meant the space or area, moving through a street system in accordance with the progression of signals, within which vehicles may pass the intersections of the street system without being stopped by the signals, whether said space or area actually contains traffic or not.

It is an object of the present invention to combine the advantages of the synchronous and of the progressive systems and to provide an unlimitedly flexible progressive system, wherein a vehicle may proceed uninterruptedly in either direction, north-south or east-west, yet the direction of preponderating traffic may be given a major proportion of the moving time.

It is a further object of the invention to provide for a variation of the proportion of moving time allotted to through and cross traffic at individual street intersections.

It is a further object of the invention to provide means wherein individual street intersections may have the moving time equally divided between the two directions while other intersections in the same system may have various proportions allotted to the two directions.

It is a further object of the invention to provide a system in which a major proportion of moving time may be allotted to traffic moving in one direction in one portion of an area and a minor proportion may be allotted to the same direction in another portion of the same area. It is a further object of the invention to provide a system in which a continuously moving traffic train may be varied in length during its progress to agree with the amount of traffic.

It is a further object of the invention to provide a system which may be started into operation by displaying, at each intersection, first a "caution" signal followed by a "go" signal for its full normal period which will serve to initiate immediately the movement of traffic trains of full normal length, to reduce confusion at starting, and which may also be cut out of action at each intersection at the end of a full normal period of signal display to insure the passage of entire trains past intersections before allowing interference of uncontrolled traffic.

It is a further object of the invention to provide signals, which it is preferred to designate as "phantom" signals, in long blocks at points at which intersections would occur if intermediate perpendicular short streets were cut through, and in other intermediate points, such as on diagonal streets between intersections, and elsewhere in order to keep traffic "in step" and to serve as an index to the proper speed along such blocks to enable such traffic to arrive at the end of such blocks at the correct time for continuous movement.

It is a further object of the invention to provide a system having means for the division of the moving time into three or more parts at intersections of more than two streets, and at normal crossings where a special left turn period is desired.

It is a further object of the invention to provide a system for controlling traffic through diagonal streets cutting across rectangular blocks so as to secure the progressive movement of traffic on all of said streets.

It is a further object of the invention to provide a system having provision for controlling traffic during a fire to group traffic in selected areas and provide a relatively clear path for fire apparatus past held traffic.

It is a further object of the invention to provide means controllable from a fire engine house to group traffic in selected areas and provide a relatively clear path through a definite run of the fire apparatus.

It is a further object of the invention to provide a system in which individual signal stations may be taken over by an officer for manual control without interfering with the automatic control of the remainder of the system even though the central control apparatus be out of action.

It is a further object of the invention to provide for the manual locking of individual signals in a fixed position to provide for the continuous display of a "stop" signal for one direction at an individual intersection without interfering with the normal operation of the "caution" and "go" signals for the cross direction at that intersection, in order to provide for blocking off a single street or an area for such occasions as parades or fires.

It is a further object of the invention to provide a system in which "go" signals bear an indication of the necessary speed to permit of continuous movement of the vehicle past the next intersection.

It is a further object of the invention to provide an unlimitedly flexible progressive system in which a dual common timer is provided so constructed that, for a given direction, the mid-point of the time of the "go" signals of each portion is substantially synchronized with the mid-point of the time of the "stop" signals of the other portion.

It is a further object of the invention to provide a system as stated in which are utilized a plurality of dual timers giving different proportions of times to "go" and "stop" signals with provision to connect any individual signal to the timer giving the desired proportions of the time cycle.

It is a further object of the invention to provide a system that may be operated by a small number of wires carried successively to the signal stations.

It is a further object of the invention to provide a system to which electrical energy may be added at various points to carry the load and to reduce the wire sizes required.

It is a further object of the invention to provide a system in which certain or all of the signals may be operated through more than one path for the electric energy.

Further objects of the invention will appear from the following description when read in connection with the accompanying drawings showing illustrative embodiments of the invention, and wherein:—

Fig. 1 is a diagrammatic view showing one relative time relation of various signals in the system to each other;

Figs. 2 to 9 inclusive are diagrams of streets indicating schemes of signals and movement of traffic therealong and past intersections thereof in the single time relation shown in Fig. 1;

Fig. 10 is a diagram of streets showing certain streets not cut through resulting in a long block on other streets;

Fig. 11 is a diagram of streets where one street cuts across a network of other intersecting streets;

Fig. 12 is a diagram of circuits at a central control station;

Fig. 13 is a diagram of circuits at a street intersection;

Fig. 14 is a diagram of circuits for fire control of traffic through a selected route only;

Fig. 15 is a diagram of circuits at a street intersection such as shown in Fig. 11 where three streets intersect.

In accordance with the invention the signals at the intersections of a network of intersecting streets are connected alternately into two series of signals, the signals at certain of the intersections being indicated by a rectangle which will be referred to as "A" signals and at alternate intersections the signals are indicated by diamonds and will be referred to as "B" signals.

In the scheme of illustration adopted in Figs. 2 to 10 inclusive, the diamond or rectangle when turned with its longest dimension coinciding with the axis of a street indicates that at that time the signal is set for "go" at that street and when turned with their longest axis across the street indicates that they are set for "stop" at that time upon that street.

Caution periods are indicated by placing the diamond or rectangle at an angle to the axis of both streets.

In Fig. 1 the dot and dash lines cutting across the time-interval-showing belts upon the diagram indicate the nature of the signal upon A and B circuits at the moment illustrated by the figure whose number appears above the dotted line. Thus dot and dash line "2" will indicate the condition of the signals in Fig. 2 at the moment of time they are illustrated. As shown, the east-west intersections, carrying A signals, have just entered upon the "go" period of time as indicated by belt **20**, which reads from left to right in Fig. 1 beginning with the dot and dash line "2", and the B signals are at an intermediate point of their "go" period upon east and west streets as indicated by the belt **21**. The broken line at the right hand end of belt **21** in Fig. 1, and at the left hand end of the same belt in this figure, indicates that the time interval indicated by belt **21** is continuous from the right hand end of the figure up to the dot and dash line **3** of Fig. 1.

The illustrations of Figs. 1 to 9 inclusive are chosen to illustrate a preponderance of east-west traffic and where in accordance with such preponderance the east-west traffic is given substantially 75% of the moving time at each intersection and the north-south traffic is given 25% of time, one-half of the "caution" periods being deducted from each of the percentages. The traffic trains which result from the operation of the signals are indicated in these figures diagrammatically by arrows. The direction of movement is indicated by the direction in which the arrow is pointed for each train, and the relative lengths of the trains are indicated in the central portion of the figures by the relative lengths of the arrows. The position of the front ends of trains entering the figures is indicated by the points of the arrows, but such trains are broken away at the boundaries of the figures. To avoid confusion, the area within the figures is illustrated in Fig. 2 as clear of traffic trains, except for the trains beginning to enter the boundaries. The figures in their numerical order illustrate the progress of only these trains, with others which subsequently enter the area. As previously stated, the term "traffic train" refers not to actual moving vehicles, but to the space within which a moving vehicle may pass street intersections in accordance with the progression of the traffic signals without stop.

At the moment when the A signal upon D Street at 1st Street, Fig. 2, is turned to "go", a traffic train indicated by an arrow **23** has just reached said intersection and the B signal upon D Street at 2d Street is also still set for "go" as indicated by the belt **21**, no recent change having been made in the B signal at 2d Street.

During the interval of time between Fig. 2 and Fig. 3, the traffic train **23** has crossed the intersection of 1st and D Streets to the position shown in Fig. 3 and a traffic train **24** is just approaching D Street on 2d Street.

At the instant indicated by Fig. 3 and by dot and dash line "3" on Fig. 1, the B signal at 2d and D Streets is turned to "caution", traffic train **24** being at this instant approaching the "caution" signal. Also a traffic train **25** traveling west on D Street has reached a position across 3d Street corresponding to the position of train **23** travelling east across 1st Street.

In Fig. 4, which corresponds to dot and dash line 4 on Fig. 1, the caution period at 2d and D Streets has ended and the traffic train **24** has the "go" sign upon 2d Street, the trains **23**, **25** being still in motion approaching said intersection.

In Fig. 5 the short traffic train **24** has passed the intersection of 2d and D Streets, the signal at which crossing has changed to "caution", and the heads of trains **23** and **25** have almost reached said intersection, having a distance to travel which will be covered during the "caution" period at 2d and D Streets.

At the instant of time shown in Fig. 6, the B signal at 2d and D Streets has turned to "go" whereby it has been unnecessary for the traffic trains **23** and **25** to stop and traffic train **24** has passed this intersection and is still in motion toward the intersection of 2d and E Streets.

It will be noted that from the beginning of the interval shown in Fig. 2, the A signals at 1st and D Streets and at 3d and D Streets have been continuously turned to permit movement along D Street.

In Fig. 7 traffic train **23** has entirely passed the A signal at 1st and D and traffic train **25** has entirely passed the A signal at 3d and D, which signals have turned to "caution" and are being approached by north-south bound traffic trains which will not be stopped as these signals are about to show north-south "go" as indicated in Fig. 8 and in Fig. 8 traffic trains **23** and **25** are still proceeding across 2d and D Streets.

Fig. 9 shows traffic trains **23** and **25** still proceeding across 2d and D Streets, their heads having reached a position at the caution distance from 3d and D Streets and 1st and D Streets respectively, which corresponds to the interval immediately preceding that shown by Fig. 2, the "caution" position of the A signals being the "caution" position which immediately precedes the A "go" period shown in Fig. 2.

It will thus be seen that both north-south and east-west bound traffic are allowed to proceed continuously along their respective streets. The interval periods **20** and **21** for "go" east-west and "stop" north-south upon the A and B signals respectively are of the same length. So also are the time belt **26** for A signal "go" north-south and "stop" east-west and the time belt **27** for B signals "go" north-south and "stop" east-west. Also the "caution" period belts **28**, **29**, **30**, and **31** are of equal length throughout.

It will also be seen that the central point of belt **27** which indicates "go" north-south upon the B signals coincides with the central point of belt **20** which indicates "go" east-west on the A signals, the overlapping of the "go" periods in these two directions being permissible because of the alternate relation of the A and the B signals upon each street. Similarly the central point of the belt **26** indicating "go" north-south upon the A signals coincides with the central point of the "go" east-west of the B signals as indicated by belt **21**, and in each case "go" east-west or north-south corresponds to "stop" north-south or east-west respectively.

The foregoing description in connection with Figs. 1 to 9 inclusive is simply for the purpose of illustrating how a simple dual interlaced signal system progresses traffic continuously in all directions over a network of streets in accordance with traffic demands which preponderate uniformly in one direction over the cross direction. By using two of any of the standard variable timers now commonly used with the so-called "synchronous systems" for the two phases "A" and "B" of Fig. 1, and maintaining the required phase angle between the two, a system of "progressive" control may be made variable at will for one general direction uniformly as against the cross direction.

Since traffic conditions and demands are continually varying from intersection to intersection, and at the same intersection at different hours, it is desirable that a system be made unlimitedly flexible in order to meet these demands.

To accommodate these irregularities, this invention provides a plurality of suitable, fixed-proportion, dual interlaced systems, having a common drive, with the mid-point of corresponding signal displays in each system having like angular position in the cycle, each of the plurality of systems being made available selectively at each intersection for use by the signal control stations, as may be desired at the individual intersections.

As the mid-point of a signal display corresponds to the mid-point of the resulting train or of the clear space between trains, the maintenance of proper relation between all of the mid-points of all the systems insures a corresponding position of the train and void center points of all the systems. Varying the proportion of the cycle time devoted to "go" and "stop" signal periods while maintaining common midpoints, results in either an earlier or a later display of the given signal by an equal amount at the beginning and ending of the period, and the train or void length will be lengthened or shortened equally at front and rear ends.

By the selection of the control means at any signal station giving the relative proportion of time to through and cross traffic needed at that intersection, each signal station along a given street may be using a different time proportion for its signals from the proportions used at either the preceding or the succeeding signal station, and the traffic trains controlled by these stations may be progressing at a uniform speed while varying in length at each intersection. As noted later, the speed of the trains will also be varied to agree with variation in length of blocks, and the coordinated signals will cause the arrival of the mid-point of each train moving in one direction at any intersection to be coincident with the arrival of the mid-point of trains moving in the cross direction at adjacent intersections.

It will be evident that as a train progresses in continuous movement along a street, when it reaches a section in which traffic becomes heavy because of influx of vehicles, the train should be lengthened; and when it passes into a section where traffic is lighter because some of the vehicles have left the street, the train may be shortened for the benefit of cross traffic.

For continuous movement in an alternated color signal system, the time cycle of lights must be of such duration that the change to a "go" signal will come at exactly the instant a car traveling at the prescribed speed from the beginning of a signal block arrives at the beginning of the next. Lengthening the time cycle simply demands that the traffic move slower if it would progress without stop, and conversely, shortening the time cycle requires that the traffic move faster to keep from being trapped within the block by the "stop" signal.

In the development of any progressive system, there are two dependent variables, the time cycle and the rate of speed, since the block length is fixed in any city. The time cycle has practical limitations. If it is made too long, traffic will be slowed too much and it cannot be shorter than the time required for a pedestrian to cross the street safely (in the absence of safety islands). With the block length fixed, the traffic train speed varies inversely with the length of the time cycle. To increase the traffic speed, the time cycle should be as short as is practical.

Cross traffic is a problem connected only with the use of the common crossing area and is provided for in this system by dividing the cycle into proportions of "go" signals suited to the demands of cross and through traffic. The amount of cross traffic has nothing to do with the length of the time cycle.

In the illustrated final form of this plurality of two-phase dual interlaced systems, a number of economies have been effected in central office apparatus and feed lines by the use of interlocking and reversing features, whereby certain parts are made to serve for more than one purpose, thus reducing the number of wires, timers, etc.

However, throughout the evolution, the essential maintenance of a phase angle of 180° in the total time cycle has been preserved between the central time point of a given signal for a given direction at one signal station and the same point of like signal at the next succeeding normal intersection signal station. This accomplishes a comparable signaling relation between the "A" and "B" stations to that illustrated in the simple form of Fig. 1, and as though the "dual interlaced circuits" were actually provided upon a plural basis with each circuit connected to alternate signal stations, even though these signal stations are not at street intersections.

To bridge the transition through several steps in the evolution of this system, the following explanation will show the relation of the features and their functions. Relays operating on the electric balance principle are provided at the intersection signal stations, as shown in Fig. 13, for actual control of the signal lamps. The relays at intersections corresponding to the rectangular symbol locations in Figs. 2 to 9 form an A group of control stations and the relays at the diamond symbol locations form a B group of control stations. The outside legs of all relay balances are permanently connected to the outside potential lines **37** and **47**. The middle points of these relays are supplied with various relative potentials to the lines **37** and **47**, through five control lines from a central office mechanism and autotransformer taps shown in Fig. 12, any one of the five lines being capable of selection at will at any station. Each of the five signal station control lines originates in a contact arm operated by cams **32**, **33**, and **34** to give three different potential connections from transformer **119**, (Fig. 12), the terminal ends of which connect across potential lines **37** and **47**.

Each of these potential connections operates to bring all of the signal station relays which happen to be selectively connected to the line to which it is applied to a corresponding definite position of their contact arms **130**, (Fig. 13). The center contact and potential of these three operates to give a "caution" signal.

It will be noted that there is a phase angle of 180° of the cam cycle between the arms actuated by cams **32** and **33**, whose peripheries are so divided into segments of different radii that they give unequal proportions of their cycle to two of the operating potentials. Cam **34** operates only one arm and control line since it gives equal proportions of cycle time to each of the two main operating potentials.

Cams **32**, **33**, and **34** are fixed upon their common driving shaft in such position that the central points of the segments having the longest radius line up, as do also the central points of the cam segments having the shortest radius. This synchronizes the mid-time point of each of the two resulting potentials on each of the lines feeding from contact arms of like angular position in the cam cycle, as arms **116**, **160**, and **164**, and wires **114**, **221**, and **224**; also arms **158** and **161**, and wires **233** and **231** respectively.

At the intersection signal stations, these applications of given potentials for definite periods with fixed angular relations in the time cycle are translated into the desired traffic signals of the proper duration and phase values as described later in detail.

For control of the signals in the system, there is illustrated in Fig. 12 a series of circuit closers **32**, **33**, and **34**, circuit closer **32** being designed to give signals for one direction of traffic 75% of the "go" time while for the cross direction signals are being given 25% of the "go" time or vice versa. Circuit closer **33** is designed to give the respective signals a proportion of 60% to 40% and circuit closer **34** is designed to give each "go" signal one-half of the total moving time.

The remainder of the illustration of Fig. 12 shows diagrammatically the circuits and apparatus for starting the system into operation, for stopping the operation of the system, and for manipulating the signals in case of fire.

For purposes of illustration in connection with Figs. 2 to 9 inclusive, the A and B signals in said figures are assumed to be placed under control of circuit closer 32 and to be properly connected to give the east-west traffic 75% and the north-south traffic 25% of the moving time, the "A" signals receiving their control through cam contact arm 116 and the "B" signals receiving their control through cam contact arm 158, these arms being spaced diametrically opposite each other in contact with the rotating cam member of the circuit closer 32 so that the phase angle between them is substantially 180° of the cycle. The rotary cam elements of the circuit closers 32, 33, and 34, with the commutator drum 82, are secured on a common shaft driven at a fixed speed by the motor 35.

When it is desired to start the system into operation, the motor 35 and the cam shaft having first been set into motion, a circuit closer 36 will be momentarily operated closing a circuit from power line 37 through wire 38, wire 39, normally closed contacts 40, wire 41, contacts 42, wire 43, solenoid 44, wires 45, 46 to the opposite power line 47. The power lines 37, 47 are shown as continued through a cable of a plurality of conductors to a signal control box shown at the right of Fig. 13.

By the circuit just traced solenoid 44 will be energized by which means contacts 48, 49 and 50 will be closed and contacts 51 and 52 will be opened, contacts 51 and 52 being interlocking control contacts for the fire and stop controlling circuits respectively.

By closing contact 48 a holding circuit will be closed through solenoid 44 from wire 47 through 46, 45, solenoid 44, contacts 48, wire 53, which is a bus wire, connecting with each of contacts 54, 55, 56, 57, and 58 by means of wires 59, 60, 61, 62, and 63. The last named contacts are in contact with the lower portion of heads 64, 65, 66, 67, and 68 from which heads the holding circuit will be closed through wires 69–73 inclusive and by bus wire 74, to the other side of the circuit at wire 37. The arms or walking beams 77–81 inclusive will remain in their central position until the commutator drum 82 has turned to bring one of the segments thereon into contact with two of the brushes 84, one of each pair of brushes 84 being connected respectively to one of each of pairs of solenoids 85–94 inclusive. The commutator drum 82 with its connections forms a delayed-action mechanism for the sequential starting and stopping of the system and for the sequential stopping of traffic in preparation for movement of fire apparatus, as described later.

The commutator drum 82 is mounted on the same shaft with the rotary cam elements of the circuit closers 32, 33, and 34, and the contact segments of the commutator drum each corresponds to one of the "caution" periods produced by revolution of the circuit closer cams.

As each "caution" period segment on the commutator drum comes into its first contact with a pair of brushes 84, after the pushing of the starting button, a circuit will be closed through one of the solenoids 85, 87, 89, 91 and 93.

In the initiation of the circuit through the A signal shown in Fig. 13 as corresponding to the signal at 1st and D Streets, Fig. 2, the actuating circuit for the solenoid 85 will be as follows: line 37, wire 76, contacts 50, wire 95, wire 75, wire 96, brush 97, continuous band 98 of the drum, segments 99, brush 100, wire 101, wire 102, solenoid 85, wires 103, 104, contacts 49, wire 46 to the other side 47 of the line.

Continued revolution of drum 82 will result in closing the like circuit through each of solenoids 87, 89, 91, and 93 to cause the walking beams 78–81 inclusive to be tipped downwardly at their left ends when the first "caution" period arrives in connection with each of the arms of the circuit closers 32, 33, and 34. The depression of the walking beams 77–81 inclusive will result in breaking the contact between the heads 64–68 inclusive and the contacts 54–58 inclusive whereby the solenoid 44 will be released and the control apparatus at the bottom of Fig. 12 will be returned to the position shown in full lines in the drawings, but the walking beams, by such means as indicated at 105, comprising a gravity member seating in recesses 106, 107, or 108 will retain the walking beams in the position to which they are brought by action of the solenoids. In this position of the walking beams switches 109–113 inclusive will be thrown upwardly and in the circuit to the signal control shown in Fig. 13 will connect wire 114 with wire 115 which leads to the signal control.

At the "caution" period under consideration, the arm 116 of circuit closer 32 will be in contact with 117 thus providing a path for current from the potential point 118 of autotransformer 119 through wire 120, contact 117, arm 116, wire 114, contact 121, wire 115, socket 122, through a plug 123 inserted therein, wire 124 to solenoids 125, 126; from solenoid 125 through wire 127 to line 37, and from solenoid 126, wire 128 to line 47, which lines 37 and 47 are continuous through the cable from the central station.

Since the point 118 is connected to transformer 119 at a point nearer 37 there will be a greater difference of potential for current passing through solenoid 126 than through solenoid 125 which will cause the walking beam 129 to assume an intermediate position bringing its arm 130 upon "caution" contact 131, thus providing a path for current through all the "caution" lights at the corner of 1st and D Streets by the following path: wire 37, the "caution" lights 132, wire 133, 134, contact 131, arm 130 to wire 47, thus displaying the "caution" signals.

Upon continued revolution of circuit closer 32, the arm 116 will be brought into contact with 135 thus providing a path for current from wire 37 past the end of transformer 119 through wire 136, contact 135, arm 116, wire 114, contact 121, wire 115, socket 122, plug 123, wire 124, to solenoids 125, 126, and thus to wire 127. Since the solenoid 126 will then receive the entire difference of potential between wires 37 and 47, and solenoid 125 will receive none of the difference of potential, being substantially short circuited, the walking beam 129 will be moved to the exterior position shown in Fig. 13, thus closing a path for current through east-west "go" lamps 137, wire 138, normally closed switch 139, wire 140, reversing switch 141, wire 142, "go" contact 143, arm 130, to wire 47, thus displaying the "go" signals for east-west traffic at 1st and D Streets. There will also be closed a circuit through north-south "stop" lights 144 at said intersection through wire 145, switch arm 146, wire 147, reversing switch 148, wire 149, contact 150, arm

130, to wire 47, thus displaying the "stop" lights at said intersection.

Continued revolution of circuit closer 32 will cause arm 116 to contact with 151 thus closing a circuit from wire 37 to wire 47 through the solenoids 125, 126 at the intersection control apparatus as follows: wire 37 and wire 47 or transformer potential 119, at point 152 thereof, wire 153, contact 151, arm 116, wire 114, contact 121, wire 115, socket 122, plug 123, wire 124, the solenoids, and thus to wires 37 and 47.

In this position of arm 116, which in passing thereinto has contacted with "caution" contact 117 thus again closing arm 130 with contact 131, the greater portion of potential between wires 37 and 47 will be impressed upon solenoid 125 and the lesser portion upon solenoid 126, thus tipping the walking beam to an intermediate reversed position from that shown in Fig. 13 wherein arm 130 will connect with contacts 154, 155, thus closing circuits through north-south "go" lamps 156 and east-west "stop" lights 157.

Continued revolution of circuit closer 32 will repeat the cycle already described so long as the walking beam 77 remains in its tilted position described.

The circuits traced are common to all A signals which are given a ratio of 75% "go" east-west and 25% "go" north-south of the total cycle. The opposite arm of circuit closer 32 will likewise control all B signals allotted a like proportion of time in the case of which signals the arm 158 will control the circuits at the central station through contact 159. Likewise the arm 160 of circuit closer 33 will control A signals given a proportion of 60% to 40% and the arm 161 will control B signals given a proportion of 60% to 40% of the moving time, the latter arms working through contacts 162 and 163 respectively.

All A and B signals will be controlled in common by arm 164 of circuit closer 34 through contact 165, the red and green lights in one direction being closed by one of the outside contacts of circuit closer 34 and the green and red lights of other switches being controlled by the other outside contact of said circuit closer, the central contact controlling all of the "caution" signals at intersections which will give a 50%–50% ratio.

When it is desired to stop the system, the action is likewise brought about at a "caution" period at each signal station and is accomplished by closing circuit closer 165′, thus providing a path for current from wire 37, the circuit closer wire 166, contacts 51, wire 167, contacts 168, wire 169, solenoid 170, wires 171, 172, to wire 47, thus closing a holding circuit to solenoid 170 via wire 47, wires 172, 171, contacts 173, closed by energization of the solenoid, wire 174, bus wire 175, wires 176–180 inclusive, heads 64 to 68 inclusive, wires 69–73 inclusive, bus wire 74 to wire 37.

The solenoid 170 will thus remain energized until current has been passed through each of solenoids 85–94 inclusive by the path as follows: wire 37, wire 181, contact 182, wire 183, wire 75, wire 96, brush 97, continuous band 98 of drum 82, a "caution" segment upon the drum 82, through alternate brushes 84, solenoids 86—88—90—92—94, wire 184, wire 185, contact 186, and wire 172 to 47, and also through the other alternate brushes 84, solenoids 85—87—89—91—93, wire 103, wire 104, contact 186′, and wire 172 to 47.

As solenoids 85—86, 87—88, 89—90, 91—92, 93—94 being paired on opposite ends of the walking beam arms 77, 78, 79, 80, 81, respectively, are energized in pairs with full and equal potential through the commutator 82, they will, due to the position of their respective armatures draw the walking beams 77–81 to the central position upon which the solenoids will become deenergized by breaking the holding circuit previously established at heads 64–68 inclusive, and the arms will be stopped at their central position opening the switches 109–113 inclusive leading to the apparatus of Fig. 13, and each intersection signal will be thrown out of action at a "caution" period, the moving element 129 and 130 of the signal relay being so balanced and weighted that it will return to a central "off" position. Since no subsequent "stop" light is displayed at each intersection, traffic will proceed without control.

As traffic increases or decreases in volume in passing along a given street, due to turns into or out of a given lane, causing a wide variation in the proportions of through and cross traffic at various intersections, and at the same intersection at different hours, provision is made in this system for adjusting the length of the trains at each intersection in accordance with the traffic demands at that particular intersection. This is accomplished by connecting the signal relay at that intersection to the circuit controlled by the circuit closer having the desired proportions of signal display in the time cycle.

The operation will then be that as a particular train passes continuously along a street, through areas of different proportional traffic densities, as between the through and cross directions, it will be lengthened or shortened in accordance with the varied demands by coming under the control of signals whose control relays are connected to the proper circuit to meet the local requirements, in all cases without interfering with the continuous movement of any train.

To change the proportion of time given to "go" and "stop" signals at the station represented in Fig. 13, the plug 123 may be shifted to the socket 220 thus providing a path for current from arm 160 through wire 221, contact 162, wire 222, whereby to provide a "go" time of 60% instead of a former 75% and a "stop" time correspondingly changed. If the plug 123 be placed in the socket 223, a path for current will be provided from arm 164 through wire 224, contact 165, wire 225, thus providing a proportion of "go" to "stop" of 50%–50%.

It is an important feature of the invention that only a minimum number of wires need be carried through the cable to the intersections successively to operate the system. Fig. 1 shows a proportion of east-west "go" of 75% and a north-south "go" of 25%. If exactly the opposite proportion were required, Fig. 1 would need to be inverted. A time interval of the value of that shown at 27 for north-south "go" would then occur in the position of interval 20 for east-west "go", and vice versa.

Since all control wires, both "A" and "B" phases of all proportions are conducted to all stations, and a station is made "A" or "B" by the relation of its signal positions in the cycle, any station may be made "A" or "B" at will.

All the "A" stations are displaying the mid-point of their "go" signals in a given direction at the same instant whatever the duration of the signal period may be at any station and all of the "B" stations are displaying the mid-point of their "go" signals for the cross direction at the same instant.

By the provision of reversing switches at the intersections, as shown in Fig. 13, the circuit closers 32 and 33 are enabled to serve instead of additional circuit closers for the reversal of time interval proportions at intersections and the two wires which are shown leading from each of these circuit closers are enabled also to serve the purpose of the additional two wires which would have to be led through the cable from each of the additional circuit closers, and the control solenoids 85–94 inclusive at the central station are also halved in number. Moreover, the reversing switches referred to enable the "stop" and "go" periods controlled by the 50%–50% circuit closer 34 at the central station to be reversed, giving the equivalent of the opposite phase value, thus resulting in a clearly reduced number of wires and control apparatus necessary to produce the results procured by the present invention. These reversing switches, shown as 141 and 148 in Fig. 13, actually reverse the signal direction and are mechanically interlocked with the control plugs making connections so that the arms 158, 161 formerly controlling "B" signals now control "A" signals, and vice versa, for arms 116, 160 so as to prevent any error in the operation. They give the opposite time proportions from those previously described as supplied by the circuit closers 32 and 33 for a given direction of traffic movement.

The means for interlocking referred to comprise the sliding plate 226 diagrammatically indicated in Fig. 13 carrying an arm indicated by dotted lines at 227' which arm by movement of plate 226 downward reverses the reversing switches shown in such figure, after which the plug 123 may be placed in either of sockets 227 or 228, the holes 229, 230 in the sliding plate being brought into registry with the sockets 227, 228. When the plug 123 is placed in the socket 227, a path for current will be provided from arm 161 through wire 231, contact 163, wire 232, socket 227, for 40% east-west "go" time. If the plug 123 be placed in socket 228, a path for current will be provided from arm 158 through wire 233, contact 159, wire 234, to the last named socket 228 for 25% east-west "go" time, thus enabling the operation of signals in Fig. 13 to be so controlled as to use any proportion of "go" time provided for at the central station along either street at which the station is located.

The showing of Fig. 13 has been described as an "A" station, the opposite or "B" stations being similar to the showing in Fig. 13, except in the reversed relation between the reversing switches 141 and 148 and the position of the sliding plate 226, shown directly connected to the switches by bar 227' (shown in broken lines), and, considered as applying to east-west traffic at a "B" signal, the sockets will give the reverse proportion of "go" time, viz.: 122, 25%; 220, 40%; 223, 50%; 227, 60%; and 228, 75%.

Obviously other time proportions may be provided throughout the system by merely changing the rotating member of the circuit closers at the control station for ones of the desired proportions; also a system may embrace a greater or less number of time proportions than are shown in the illustrated form.

If it be desired to take over the control of signals at the station in Fig. 13 manually by a traffic officer at the intersection, the same may be accomplished by merely manipulating the arm 129 as by means of handle 235, thus overcoming the successive energization of solenoids 125, 126. When the signal system is placed out of operation by pressure of the "stop" circuit closer 165' at the central station, the weight of the handle may operate to bring the walking beam 129 to a central position out of contact with the control contacts coacting with arm 130.

By reference to the diagram, Fig. 13, it will be obvious that the above mentioned control of signal display by hand may be effected whether the central station timers are in operation or not, as may also the signal blocking operations described in the succeeding paragraph, since the power lines 37 and 47 are to be kept alive at all times. Another point to be noted is that the signals displayed by any fixed position of the hand operation may be used continuously whenever desirable, whether or not the central office timers are in operation. Any of the signal combinations obtainable by automatic operation may be obtained by manual operation.

If it be desired to block off a street or area, the "stop" lights at stations entering upon said street or area may be placed into operation by manual closure of switches 146 or 213 with the contacts 236 and 237 respectively. A circuit will thus be provided from wire 47 through wires 238, 239, contact 236, switch arm 146, wire 145, north-south "stop" lamps 144, to wire 37, which lamps will be continuously operated or from wire 47, wire 238, wire 239, contact 237, switch arm 213, wire 212, through east-west "stop" lights 157, which will also be continuously displayed until the switch arm 146 or 213 is restored to the position shown in Fig. 13. Such movement of manual switches will also break the circuit through wires 140 and 144 controlling the "go" lights at the station to prevent their display by the continued action of walking beam 129 which is not interfered with. It is obvious that the operation of both switch arms 146 and 213 will provide the equivalent of a fire stop at the intersection in question. For purposes of blocking off such intersection in the case of a parade the appropriate arm 146 or 213 may alone be operated to display either east-west "stop" or north-south "stop" leaving the signals of the cross direction in operation under control of walking beam 129 so that traffic along one street will not be interfered with.

There is shown an audible signal as a bell at 240 which is normally sounded at each "caution" period by a circuit from wire 37 to the bell, wire 241, switch arm 242, wire 134, of the "caution" circuit. If it is not desired to sound the bell, the switch 242 may be manually opened to cut the same out of action.

It will be observed that the sequential starting, stopping, and fire signal control is accomplished in such manner, by means of the interlocking and holding contacts, that any one of these operations, once started by momentary closure of the buttons 36, 165', or 187, will be completed before another can be started. Also any of these operations may be put into effect regardless of which other operation has preceded it.

In the case of fire, when it is desired to stop traffic through the entire area under the control of a particular central control apparatus, the circuit closer 187 is operated, providing a path for current from wire 37 through wire 38, circuit closer 187, wire 188, contacts 52, wire 189, contacts 190, wire 191, solenoid 192, wire 193, to wire 47, thus energizing the solenoid 192 and closing a holding circuit from wire 47 through the solenoid 192, contacts 194, wire 195, to bus wire 196, each of contacts 197 to 201 inclusive, heads **64** to **68** inclusive, wires **69** to **73** inclusive, bus wire **74** to wire **37**, and the energization of solenoid **192** will close contacts **202** and **203**, thus providing a path for current for solenoids **86**, **88**, **90**, **92**, and **94**, that through **86** being as follows: wire **47**, contacts **202**, wire **185**, wire **184**, solenoid **86**, wire **204**, the upper brush **84**, "caution" period segment upon drum **82**, band **98**, brush **97**, wire **96**, wire **75**, contact **203** to wire **37**. A like circuit will exist through each of the other solenoids **88**, **90**, **92**, and **94** by means of wire **184**, wires **205**, **206**, **207**, and **208**, through the corresponding brushes **84**, the segments on drum **82**, band **98**, brush **97**, wire **96**, wire **75**, contact **203**, to wire **37**.

The result of thus pressing the fire signal control circuit closer **187** will be that the right hand end of walking beams **77** to **81** inclusive will be depressed at the next succeeding corresponding "caution" period, thus causing switches **109**, **110**, **111**, **112**, and **113** each to close with the lower contact to complete the circuit, which for 2d and "D" Street signals is as follows: the wire **47'** at the right hand end of transformer **119**, switch **109**, wire **115**, socket **122**, plug **123**, wire **124**, solenoids **125**, **126** to wires **47** and **37** respectively at the control station. By this connection, the entire potential between wires **37** and **47** will be placed upon solenoid **125**, Fig. 13, causing the walking beam **129** to be thrown completely downward thus bringing the arm **130** upon contacts **209**, **210**, and **211**, thus closing a circuit through both north-south and east-west "stop" signals at this station, and at all other stations controlled by the same polyphase circuit wire, and also through an audible fire signal at the same stations. Since the solenoids **86**, **88**, **90**, **92**, and **94** will be energized only at the beginning of a "caution" period, (the action of commutator **82**), the fire signals at the separate intersections will not all be initiated simultaneously but only at the beginning of a "caution" period for each intersection.

Figs. 1 to 9 illustrate a system operating with a single time proportion cycle, in which, as will be evident in Fig. 1, there are four "caution" instants in the cycle, any of which is a possible instant for the display of a fire signal at the stations in its phase. The initiation of a fire signal display in the system by the closure of circuit closer **187** between the instants indicated by the dot and dash lines **2** and **3** in Fig. 1 will cause a display of the fire signals of the stations under the control of phase "B" at the arrival of instant **3**, but there will be no change in the signals under control of phase "A" until the arrival of instant **7**. This delay is due to the action of the segments of the commutator drum **82**.

The display of all "stop" signals at an intersection, combined with the sounding of the siren instead of the bell, coming at a normal "caution" instant, necessarily just preceding a "go" signal, will automatically stop the leading cars of each approaching train before they enter the intersection. Any signals operating with other time proportions which would arrive later at their "caution" instant, would, by displaying the all red "stop" signals at that later "caution" instant, close their crossing after the scheduled passing of the rear car in the longest trains being accommodated.

Trains moving in a section where a major portion of the cycle is devoted to one direction of travel, making their length greater than one block, as the east-west trains **23** and **25** of Figs. 5 to 9, inclusive, will be confined within one block in the following manner: Trains operating on a 75% portion of the cycle will be less, by the "caution" distance, than one and a half blocks long, requiring a shortening of the trains by less than one third of their length, and there will be spaces between vehicles following each other in the train equal to the vehicle length or more, or a solid density of not more than 50%.

For illustration, if the first display of the fire "stop" occurs in front of the leading cars of trains **23** and **25** approaching the "B" signals at the instant of Fig. 5, a packing together of all cars in the trains as they come to a stop will result, easily reducing the length of the stopped traffic trains during the time elapsed between the instants of Fig. 5 and Fig. 7 so as to clear the intersections of 1st and 3d Streets with "D" Street behind trains **23** and **25**. During this interval, the rear cars of each long train **23** and **25** will have cleared the intersections under control of the "A" signals, and the small trains, as **24**, **24'**, will have moved from the intersections under the control of the "B" signals and will be stopped at the "A" signal intersections at their arrival, which would be at the instant of display of the fire "stop" signals at the "A" stations.

With a plurality of dual interlaced systems, traffic will not be stopped simultaneously in all blocks but each train will reach the next intersection when the "caution" signal would have been displayed, and the following signal will in each case be a "stop" signal. The traffic will pack into alternate blocks and will provide a free zigzag course for the run of fire apparatus along each street alternately upon the left and upon the right, all intersections being clear.

The path for current at a fire stop through north-south "stop" signals **144** is as follows: lamps **144**, wire **145**, switch **146**, wire **147**, reversing switch **148**, wire **149**, contact **209**, arm **130**, to wire **47**.

Through east-west "stop" signals, the circuit is as follows: lamps **157**, wire **212**, switch **213**, wire **214**, reversing switch **148**, wire **215**, contact **210**, arm **130** to wire **47**. The circuit through the siren **216** would be from wire **37** to wire **217**, normally closed switch **218**, wire **219**, contact **211**, arm **130**, to wire **47**.

In cases where there is occasion for a run of fire apparatus throughout a definite route, as where after a fire alarm has been responded to by the fire department it is found desirable for apparatus from one station to run to another station for strategic disposition of reserve fire apparatus, provision is made in the system of the invention for a fire control of signals to group the trains in alternate blocks on opposite sides of the streets, leaving a clear zig-zag course for the fire apparatus throughout said definite route. Apparatus for this purpose is illustrated in Fig. 14.

As shown in Fig. 14, a control wire leading from wire **37** at the nearest street intersection is connected through to a hand switch **243** located at the fire station and a control wire **244** with the apparatus controlling each intersection, successively through the route selected. When the switch **243** is closed, a path for current is provided from wire **37**, switch **243**, wire **244**, solenoid **245** at each street intersection on the route, wire **246**, arm **247**, wire **248''**, extra contact **131'** in "caution" position, which upon the first movement of arm **130** at each intersection on the route will connect with wire 47, thus energizing solenoid 245 which attracting its core 249 will close the hold-up circuit for solenoid 245 through arm 247, arm 248′, arm 249′ via contacts 250, now closed, to wire 47. At the same time a path for current will be provided from wire 37 through solenoid 125, wire 124, arm 248′, contacts 250, arm 249′, to line 47.

In this event solenoid 126 will be short circuited since the same will be connected at its top directly to wire 47 and at its bottom through wire 124, arm 248′, contacts 250, arm 249′, to the same wire, thus putting full potential on solenoid 125 for display of fire signals, wherein the arm 130 contacts with contacts 209—210—211, which, as already explained is the fire signal position. The control path through plug 123 and wire 124 having been broken at contacts 251, normal control of signals along the selected route is interfered with until the switch 243 is again opened allowing the spring 248 to restore the parts to the position shown in Fig. 14. Springs 252 and 253 serve to hold the arms 247 and 249′ respectively in contact with stops when arm 248′ is in released position.

While the wires 37 and 47 have been shown for convenience of illustration as carried through the cable to all intersections successively it will be obvious that in cases where the signal lamps are illuminated from the city light supply the connections to the wires 37 and 47 at each street intersection may be made directly to said city light supply, care being exercised to make the connections thereinto at each intersection of proper phase, potential and polarity. This allows the lamp "load" to be carried from local supply, relieving feed cables and reducing the number of wires required.

In Fig. 15 is shown the diagram of circuits for control of an intersection of three streets, such for instance as shown at the centre of Fig. 11 where a diagonal street called X Avenue on said figure intersects with both B Street and 2d Street. At such an intersection there are obviously required "go", "stop", and "caution" lamps facing each direction upon each street. The lower right corner of Fig. 15 indicates an apparatus such as shown in Fig. 13 and the preferred mode of operating the signals at such an intersection is to give a minor proportion of time to one street, as B Street, Fig. 11, and to divide the major portion of time which upon the other streets in the vicinity is given to east-west traffic, as 2d Street, into two parts, one allowing movement along 2d Street and the other allowing movement along X Avenue.

As indicated by the legends opposite the lamps, the upper three pairs of lamps are "caution" lamps, the central three pairs are "stop" lamps and the bottom three pairs are "go" lamps, the top pair of each of the three sets being dedicated to B Street, the central pair of each set to 2d Street and the bottom pair of each set to X Avenue.

Provision is shown in Fig. 15 for a manual control of the signals at such an intersection which for convenience will first be described. Said manual control comprises a circuit closer diagrammatically shown as an arm 254 revoluble about an axis 255 and in its off position shown in the figure closing circuits to the automatic control shown in the upper right corner of said figure. If the arm be swung to the right of its position, a path will be provided for a current from wire 47 to contacts 256, 257, 258, which will close circuits via wires 259, 260, 261, to "go" signals on B Street, and to "stop" signals on X Avenue and 2d Street respectively, the current passing from said lamps directly to wire 37 connected to said lamps in parallel. Movement of the arm into contact with contacts 262, 263, 264, and 265 will close circuits through wires 266, 260, 267, and 268, to bell 240, "stop" lamp on X Avenue, "caution" on B Street, and "caution" on 2d Street. Movement of the arm into contact with contacts 269, 270, 271 will cause the circuits through wires 272 to "stop" on B Street, through wire 260 to "stop" on X Avenue and through wire 273 to "go" on 2d Street.

Movement of the arm into contact with contacts 274, 275, 276, and 277 will cause the circuit through wire 266, to the bell 240, through wire 272, to "stop" on B Street, through wire 268 to "caution" on 2d Street, through 278 to "caution" on X Avenue.

The arm 254 when moved into contact with contacts 279, 280, and 281 will close the circuit through wire 272 to "stop" on B Street, through wire 261 to "stop" on 2d Street and through wire 281′ to "go" on X Avenue. When the arm 254 is moved to contact with contacts 282, 283, 284, and 285, a circuit will be closed to the bell 240 through wire 266, through wire 261, to "stop" on 2d Street, through wire 278 to "caution" on X Avenue and through 267 to "caution" on B Street.

It will be noted that in the operation of the hand control as described above, or in the reverse rotation of arm 254, as well as in the automatic operation described in the following paragraphs, there is a "caution" signal displayed on a signal face only just preceding a change of signal display on that face, and no "caution" signal is displayed on the face which is not to be changed at the next signal change instant.

In automatic operation, the function of the contacts coacting with arm 254 will be performed by the solenoids shown in the upper right corner of the figure, except the position for "go" on B Street which is controlled directly by walking beam 129.

For control of the solenoids a motor 286 is provided operating a cam wheel 287 and a commutator drum 288. To close a circuit through the motor when the system is to be placed into operation, there is shown a wire 289 leading from the upper portion of Fig. 12 where it may be placed into connection with wire 37 by means of a manually operated switch 290. Said wire leads through the cable to the signal station to solenoid 291 and from the solenoid through wire 292 to switch arm 254 which is connected to wire 47, thus causing the solenoid to close contacts 293 and 294 whereby to close a hold-up circuit from wire 47, through contact 294, wire 295, contact 296, arm 297 when actuated, motor 286 to wire 37. Wire 47 is connected through arm 254, wire 292, and contact 293 when closed, to the wire numbered 47 which supplies energy to the arms in the upper portion of the figure, as, e. g., 320.

Assuming that the lower right corner of Fig. 15 illustrates a B signal and with the switch arm 254 locked in the position shown, a circuit will be closed from wire 124″ carrying the plug 123 to arm 298 held depressed by the end of arm 254, contacts 299, wire 300 to solenoids 125 and 126, which in turn are connected in the manner shown in Fig. 13.

Upon the first movement to the left of arm 130 the "go" signal on B Street will be actuated from wire 47, through arm 130, contact 154, reversing switch 141, wire 140, through the lamps to wire 37, and a parallel path will be closed from wire 140 through wire 301, solenoid 302, wire 303 to wire 37, thus energizing the solenoid and pulling down arm 304 and closing a path from wire 47, arm 130, contact 155, wire 215, reversing switch 148, wire 214, wire 305, contacts 306, arm 304, wire 307, wire 308, to "stop" signals on X Avenue, also on the path already traced from contact 155 to wire 214 and to "stop" lamp on 2d Street. When the arm 130 leaves contacts 154, 155, the arm 304 will again be raised closing a path from wire 47' through wire 309, the right hand end of arm 304, contacts 310, wire 311, brush 312, wire 313, contacts 314, arm 297, motor 286, wire 37, which will start the motor and will also close a path through hold-up solenoid 315 in shunt with the motor 286 which will draw over arm 297 in contact with contact 296 against the resistance of spring 316 closing a circuit from wire 47, contact 294, wire 295, contact 296, and arm 297, to solenoid 315 and to wire 37.

Revolution of the motor will first bring brush 317 into contact with segment 318 on commutator 288 thus energizing solenoid 319 to draw down arm 320, thus closing the circuit from wire 47', arm 320, contacts 321, to "caution" lamps on B Street through wire 322, contacts 323, through wire 324, to "caution" on 2d Street, contacts 325, wires 326, 327, to bell 240 and contacts 328, wires 329, 330 to "stop" on X Avenue.

Continued revolution of commutator 288 closing segment 331 with brush 332 provides a path for current from wire 47', wire 309, arm 304, contact 310, wire 311, brush 312 to the commutator and wire 333 to solenoid 334 which draws down arm 335 closing the contacts associated therewith, at the same time solenoid 319 being de-energized to release the circuits controlled thereby. The contacts 336 closed by arm 335 will provide a path for current from wire 47', wire 337, the contacts, wire 338, to "go" lamp on 2d Street, also closing the circuit through wire 47, wire 337, arm 335, contact 339, wire 340, wire 330, to "stop" on X Avenue and over the first part of the same path through contacts 341, wire 342, wire 343, to "stop" on B Street. Further rotation of commutaor 288 for bringing segment 344 into contact with brush 345 will energize solenoid 346 attracting its arm simultaneously with the breaking of the circuit through 334, thus placing "caution" signals on 2d Street, on X Avenue, closing a circuit through bell 240 and placing a "stop" signal on B Street by readily traced circuits.

Further rotation of the commutator bringing segment 347 into contact with brush 348 energizes solenoid 349 and de-energizes solenoid 346, thus displaying a "go" signal on X Avenue, a "stop" signal on 2d Street and a "stop" signal on B Street. Contact with segment 350 with brush 351 energizes solenoid 352 thus ringing bell 240 and displaying "caution" signals on B Street, X Avenue, and a "stop" signal on 2d Street.

The motor 286 is adjusted to revolve the commutator 288 to the last named "caution" period at approximately the instant when motor 35 at the central control station has brought the arm of the circuit closer thereat, which controls the operation of arm 129 to display a "go" signal again on B Street, the display of which "go" signal by closing the parallel path through solenoid 302 will break the circuit from wire 47 to brush 312. It is assumed that the "go" signal on B Street referred to is given a minor proportion of the moving time and that the major portion has been divided between X Avenue and 2d Street by the automatic control through solenoids 319, 334, 346, 349, and 352.

Breaking of the contact 310 however will not stop motor 286 since the current to the motor is still supplied by virtue of its hold-up magnet 315, the motor 286 will therefore continue to revolve for a slight additional period of time until cam 353 catches hook 354 further stretching spring 316 and until the cam slips off the hook by hammer action of lug 355 against the end of arm 297 breaking the hold-up contact 296 thus stopping the motor.

By this arrangement the "go" signals on B Street at the intersection in question will be utilized to synchronize the remaining signals at said intersection with the other A and B signal stations in the system.

It will be noted that it is proposed to operate this system of traffic control on a fixed time cycle, which requires traffic to move at speeds approximately in proportion to the block lengths to move continuously. It is not proposed to vary the length of the time cycle, therefore the traffic speed for any given block will remain constant and drivers will become accustomed to this speed and to the necessary variations for different blocks.

As longer blocks required higher speeds and a block of twice the standard length requires twice the standard speed, it is proposed to place consequent signals at the center of such long blocks which will take their regular place in alternating phase sequence, for the purpose of keeping the traffic grouped in trains and dividing the traveling distance between signals to give reasonable traffic speeds. Such a signal is indicated at 356, Fig. 10. In the position there shown the signal is indicated as an A signal placed between two B signals and at a point in a long block where an A signal would occur if a short end street were cut through. The consequent signals require only "go" and "caution" lights and may be assumed to be controlled by mechanism similar to that shown in Fig. 13, the "stop" contacts and wiring being connected to amber lights instead of to red lights and the amber light control contacts being omitted. With this arrangement the green lights upon the consequent signal would bear an indication of the correct speed for driving to arrive at the proper moment at the next street intersection and the amber lights will be displayed when a "stop" light would otherwise be displayed if the short length street were cut through. Traffic in such a block upon observing a "caution" light as they approach the "caution" signal will thus be informed that they are in advance of their schedule and must slow down if they do not desire to arrive at the next intersection too early for continuous movement.

Consequent signals are also indicated at 356 on X Avenue in Fig. 11 upon which avenue the intersection lights are indicated as B signals and the consequent signals as A signals, which will therefore synchronize the movement of traffic with the A signals along X Avenue.

With this system, using a fixed time cycle and various traffic speeds for various length blocks, traffic should be advised by signs, preferably on the signals, at what speed to travel in the succeeding block as an essential part of the system.

The following method is suggested for laying out such a system in any given city merely to illustrate the principles involved.

Establish a standard block for the area to be controlled giving due consideration to the actual short and long blocks and their importance in the area, and establish a time cycle to give a reasonable traffic speed in the standard block. This "standard block" need not be the exact length of any actual block, but it would probably be near the average length. From this standard time cycle and standard block length, calculate the proper driving speeds for each actual block and post, on each signal face, the proper speed for the succeeding block for traffic under control of that face.

Driving speeds should be increased from the standard to accommodate increase in block length up to one and one-third times the standard length, and decreased from the standard speed to accommodate decrease in block length down to two-thirds of the standard. In blocks of more than one and one-third times the standard length, a consequent signal should be inserted midway of the long block and take its place in the phase alternation system. When blocks are less than two-thirds of the standard length, one street, as **359** in Fig. 10, should be blanked off with "stop", "no-left-turn" and "no-crossing" signals and not considered in the alternating signal system, calculating and posting the speed for the composite block created by the suppression of the intersection.

To show that the general proportions of this system of speed allotments remain within reason, take for illustration a standard block length of three hundred feet, with the minimum block length two hundred feet and the maximum block length four hundred feet; then if the standard block speed is twelve miles per hour, the maximum block will have a speed of sixteen miles and the minimum block will have a speed of eight miles per hour. This illustration takes in the extremes in both directions and the longest block used is twice the length of the shortest block. Any block that was in excess of four hundred feet and split by a consequent signal would have a speed of eight or more miles per hour, while any two blocks of less than two hundred feet, would have if combined, a speed of less than sixteen miles per hour. Blocks in excess of six hundred feet may have more than one consequent signal in harmonious phase position in the system. The time cycle for the speeds in this illustration would be thirty four seconds.

Referring to Figs. 10 and 11, it will be seen that the north-south dimensions of all blocks, and the east-west dimensions of the blocks in Fig. 11 are the same, which we may assume to be the standard block length giving a standard speed, while the east-west dimensions of the signal blocks in Fig. 10 are about one and one-half this standard length and would require a traffic speed of one and one-half times the standard speed. Assuming the standard speed to be ten miles per hour, the faces of signals leading north, south, east, and west in Fig. 11 and those leading north and south in Fig. 10, would bear a legend indicating ten miles per hour, while the signals facing east or west in Fig. 10 would indicate fifteen miles per hour. The signals along X Avenue, Fig. 11, would bear indications of seven miles per hour, the hypotenuse ratio of 1.41 times the length of the standard block being divided in two by the phantom signals between intersections.

Obviously, successive blocks in the same street which are of different dimensions call for different speed signs, as for illustration, the east and west streets in Figs. 10 and 11 taken as a single continuous plan.

Consequent signals have as their function to adjust the speed of traffic at points other than the regular intersections of a network, as in unusually long blocks, or between the intersections on a diagonal street, or along a driveway through a park, or at approximately a block away from the first regular intersection signal of a controlled area, in which cases the consequent signals take their regular places in the alternating "A" and "B" phases to harmonize the traffic with the signals at the junction points with the regularly controlled network.

The cables bearing the control wires have been described as running successively through the intersections of the system. For connection of the cables there are indicated at **357** and **358** in Fig. 13 junction boards for connection to the cables it being obvious that a trunk line can be carried out a through street from the control station and by means of junction boards such as shown the branches to other intersections upon either side of the trunk line may be connected in.

In addition to this arrangement it is proposed to carry a ring cable carrying one each of the wires in the main control cable to an outlying point and to conduct this cable around the outskirts of the area connecting the same into the intersections therealong. By provision of such a ring cable two paths for control will exist to all of the intersections within the ring and should a cable be broken leading to a certain area as by demolition of a control box at a single intersection the remaining signals may receive circuit via the ring cable and therefore service will not be interrupted except at the damaged intersection. It is not considered necessary to show the connection for such a ring cable as it appears obvious.

Obviously more than one connection may be made to one cable or a plurality of cables may be provided.

While the system has been described utilizing an auto transformer for varying the potential applied to the conductors leading to the signal stations, it will be understood that direct current can be used as by floating a storage battery across the line at the control station and tapping off the desired differences of potential thereon.

It is also contemplated to use the circuits and apparatus illustrated in Fig. 15 at intersections of two streets only, using one or more of the additional periods thus secured for left turns or other special purposes.

The operation of the system will be clear from the above description. Minor changes may be made in the circuits utilized, in the character of the apparatus diagrammatically illustrated, or in the steps of the methods of the invention within the scope of the appended claims without departing from the spirit of the invention.

I claim:

1. A method of controlling traffic divided into separated trains moving on a controlled schedule, for providing for runs of fire apparatus which comprises displaying a fire "stop" signal at the "caution" period in advance of the scheduled ar-

rival of the front end of each train at the next street intersection whereby to confine the whole of each train within a single block with the opposite side of the street therein normally vacant for use of the fire apparatus.

2. The system for controlling traffic upon a system of intersecting streets which comprises a central station, conductors maintaining constant line potentials throughout the system a plurality of circuit closers at said station operating in a common time cycle, a plurality of signal stations each equipped with "go" and "stop" signals, two pairs of conductors connecting said circuit closers with each of said signal stations successively, means controlled by said circuit closers for applying different potentials intermediate to said line potentials to said conductors for different periods of time, as 60% and 40% of each time cycle by one circuit closer and as 75% and 25% of each time cycle by another thereof, the central points of equal potentials at adjacent stations being separated by substantially 180° of the time cycle of the circuit closer, means at the signal stations to display "go" and "stop" signals in accordance with the potential upon a connected conductor and means at each signal station to make connection of a "go" and "stop" signal display means to a selected one of said conductors.

3. A traffic control system comprising, in combination, means at a central station for controlling in proper phase position to give progressive traffic a display of "go" and "stop" signals on one set of streets and for controlling a display of "stop" and "go" signals on a second set of streets intersecting said first named streets, consequent signals placed in abnormally long blocks in said streets displaying only "go" and "caution" signals and means at said station for controlling said consequent signals to display "go" signals in proper phase posititon with other signals on the streets including said long blocks and to display "caution" signals for the rest of the time to give progressive traffic.

4. A traffic control system comprising, in combination, a central control station, a signal station having a plurality of "go" and "stop" signals for display in a plurality of directions, means at the central station for controlling the routine traffic display of each of said signals, means at the signal station for continuously displaying selected "stop" signals in given directions thereat and inhibiting the central station control of "go" signals for the same directions leaving the remainder of the signals at the said signal station under uninterrupted control of the central station.

5. A traffic control system comprising, in combination, a central control station, a plurality of signal stations each having a plurality of "go" and "stop" signals for display in a plurality of directions, means at the central station for controlling the routine traffic display of said signals, means at the signal stations for continuously displaying selected "stop" signals for given directions and inhibiting the display of corresponding "go" signals for the same direction leaving the remainder of the "go" and "stop" signals at that station and throughout the system under uninterrupted control of the central station.

6. A traffic control system comprising, in combination, a central control station, a plurality of intersection signal stations having "go" and "stop" signals, means at the central station to control display of said signals to cause traffic to progress in separated trains continuously past the said signal stations, and means at the central station to cause continued display of all "stop" signals as during response to a fire alarm initiating said "stop" signals at the intersections at such instant in the time cycle of signals and in such sequence as to stop the traffic trains and hold the traffic in alternate blocks on opposite sides of the streets, leaving a clear zig-zag course through the street system for use by the fire apparatus.

7. A traffic control system comprising, in combination, a central station, a plurality of signal stations, "go", "stop", and "caution" signals at said signal stations, means at the central station for controlling display of said signals and means at the central station to cause continued display of the "stop" signals initiating such continued display at the next occurring "caution" period at each signal station.

8. A traffic control system for a network of intersecting streets comprising a plurality of electrically controlled stations for displaying "go" and "stop" traffic signals in a fixed time cycle, the stations consisting of "A" stations and "B" stations alternately arranged along both through and cross streets, the "A" stations and the "B" stations forming two systems, each system under a common control, means for causing the "A" stations to differ from the "B" stations by a difference in phase of 180° in the mid-point of the time of display of corresponding signals for a given direction in said fixed time cycle which is the same for both "A" and "B" stations, and means causing the period of simultaneous display of signals to be of unequal duration in the two phases.

9. A traffic control system comprising conductors maintaining constant line potentials throughout the system, two control conductors, means for imposing in a recurrent cycle, upon said two control conductors, two principal, different, alternating control potentials each intermediate to said line potentials, each substantially constant during two different, recurrent major periods, alternating in length and definite in duration, the mid points of both major periods being equally spaced from each other in the cycle, said two conductors receiving equal control potentials alternately, the mid points of the two principal, different control potentials being synchronous in the two conductors, a plurality of stations at intersections of two streets, each having means actuated by said control potentials for displaying two different major signals, "go" and "stop", for control of traffic moving in opposite directions in each street, "go" signals alternating with "stop" signals at each station on each street and at successive stations along each street in through and cross directions, and means at each station for connecting either conductor at will to means for displaying either the "go" or the "stop" signal upon either street, for actuation during either period.

10. A traffic control system comprising two groups of control stations, A and B, for control of "go" and "stop" signal displays, the A stations being located at alternate signal locations in a network of streets and the B stations being located at intermediate signal locations in the network, a plurality of control means selectively available at control stations and operating in a common time cycle and each capable of causing a control station to display "go" signals for a different definite proportion of the time cycle for a given direction, and means for making

operative the control means causing signal display for the proportion of the common time cycle desired at that particular signal location, the system including means for maintaining a phase angle of substantially 180° of the common time cycle between the mid-time instant of any "go" signal display for a given direction at any A station and the mid-time instant of any "go" signal display for the same direction at any B station.

11. In a traffic control system as in claim 10, in which certain control means cause the display of "go" and "stop" signals for unequal proportions of the time cycle, means for converting the control intended for a "go" signal display for a given direction at an A station for a greater proportion of the time cycle into a control of a "go" signal display for the same direction at a B station for the smaller proportion of the time cycle, and vice versa.

12. A traffic control system comprising, in combination, conductors maintaining constant line potential throughout the system, a central station, a plurality of signal stations at intersections, conductors extending from said central station to said signal stations, means at said central station to apply different definite potentials intermediate to said line potentials for different definite periods of time upon each of said conductors in a regular sequence, certain of said conductors having the same sequence of definite intermediate potentials applied for the same periods as certain other conductors, in pairs, the central point of periods of like potential being spaced substantially 180° of cycle of said central station, as between conductors of each pair, the separate pairs being supplied with like potentials for periods forming different proportions of the time cycle, "go" and "stop" signals at each of said signal stations, a circuit closer at each of said signal stations to control said signals in accordance with the potential applied to one of said conductors intermediate said line potentials, means at each signal station for connecting the circuit closer with a conductor of different pairs, selectively, whereby signals for a given direction of traffic movement may be displayed for different lengths of time at adjacent intersections, while maintaining the essential alternating phase angle of the signals at adjacent intersections to produce continuous progression of traffic.

13. A traffic control system comprising, in combination, conductors maintaining constant line potential throughout the system, a central station, a plurality of signal stations at street intersections, two control conductors extending from said central station to said signal stations successively, means at said central station to apply different definite potentials intermediate to said line potentials for different definite periods of time upon each of said conductors in a regular sequence in a fixed time cycle, the central point of periods of like potential in the two conductors being spaced substantially 180° of the time cycle of said central station, "go" and "stop" signals at each of said signal stations, a circuit closer at each of said signal stations to control said signals in accordance with the potential applied to one of said conductors, said signal stations operating to display the "go" signal during the longer period of time, and the "stop" signal during the shorter period of time of the cycle for one street at an intersection, the two conductors being connected alternately to successive signal stations, and the displayed signals alternating "go" and "stop" at consecutive signal stations.

14. A traffic system comprising in combination, two interlaced systems of signal control, the signals of each of the two systems being arranged on alternate intersections of any given street of a plurality of intersecting streets, a central station having means to cause the simultaneous display for each system of "go" signals for progressive control of traffic upon streets running in one direction, as east-west, for a major portion of a time cycle, alternated at adjacent intersections with the display of "stop" signals upon said streets for a minor portion of the time cycle, and means at said station to cause a display of "go" signals for progressive control of traffic upon the streets running in the other direction, as north-south, for a minor portion of the time cycle, alternated at adjacent intersections with a display of "stop" signals for the same street for a major portion of the time cycle.

15. A system as recited in claim 14, in which the half-way point of the period of time of display of the "go" and "stop" signals of each system is substantially synchronized with the half-way point of the period of display of the "stop" and "go" signals respectively, of the other system.

16. A traffic control system for a system of intersecting streets cut by a diagonal street having a common intersection with two other intersecting streets, comprising, in combination, means at a central station for controlling the display of "go" and "stop" signals timed for continuous movement in both directions along said intersecting streets, and means for controlling a display of "go" signals upon said diagonal street at the said common intersection for a time interval subtracted from the "go" time along one only of said intersecting streets at said common intersection, alternated with a "stop" signal while a "go" signal is displayed upon either of said intersecting streets.

17. A traffic control means comprising a plurality of signal stations forming a system having two electrical controls, one controlling the signals at alternate stations and the other controlling the signals at intermediate stations, means for operating the controls to display "go" and "stop" signals through definite variable periods, in uniform time cycles, the central point of a period of display of a "go" or "stop" signal for a given direction by one control being spaced substantially 180° of the time cycle from the central point of the period of display of the corresponding signal for the same direction by the other control.

18. A traffic control system comprising in combination, signal stations at intersections of streets, means for displaying "go" and "stop" signals at said signal stations for continuous movement of traffic in trains in said streets, the said signals operating in a definite time cycle, and "consequent" signals at points other than traffic crossing lanes displaying only "go" and "caution" signals having means for displaying "go" and "caution" signals, the "go" signals being operated in accord with the time cycle and spaced from other signals to harmonize the movement of traffic toward the intersections under control to agree with the progression of traffic trains and the "caution" signals being displayed during the period in which the "go" signals are not operated.

19. A traffic control system comprising a plurality of signal stations, a central station having means controlling said signal stations for progressive traffic in a common traffic signal cycle, each signal station having means displaying routine traffic signals, the length of the time cycle and the duration of each signal being controlled from said means at the central station, the central station control means having a plurality of control means giving signal periods forming different divisions of the common time cycle and said control means maintaining synchronism of the mid-point of the time of display of like signals, each signal station having signal display means cooperating with any selected one of the said plurality of control means, a plurality of control means being available for selection at each station, whereby a desired division of the time cycle may be selected from those available to control the proportions of the time cycle allotted to signals at that station.

20. A traffic control system for a system of intersecting streets cut by a diagonal street having a common intersection with two other intersecting streets, comprising a central station having means for controlling the display of "go" and "stop" signals for continuous traffic movement in both directions at two-street intersections in the system, and control means at said common intersection responsive to central station control for the display of "go" and "stop" signals for one street only at the said common intersection, and having means automatically controlling the display of "go" and "stop" signals in a regular sequence for the other streets at the said common intersection during the period of display of the "stop" signal on the street not under the control of the automatic means at the intersection.

21. A traffic control system for continuous progression in all directions of travel, comprising a plurality of signal stations, a plurality of pairs of conductors extending to each station, means for applying similar electric controls in each conductor through a succession of definite periods in a common time cycle, comprising means for varying the period of similar electric controls in the different pairs of conductors but maintaining their midpoints displaced by 180 degrees in the said common time cycle, and in synchronism, "go" and "stop" signals at each station, means at each station responsive to said electric controls in any conductor for displaying said signals for through and cross direction in periods of a routine traffic cycle in accordance with the periods of said electric controls in said common time cycle, and means at each station for connecting said signal display means selectively with certain of said conductors whereby the signals may be displayed for either a longer or a shorter "go" or "stop" period of a traffic cycle while maintaining progressive traffic.

22. A traffic control system for continuous progression in all directions of travel, comprising a plurality of signal stations, a plurality of pairs of conductors extending to each station, means causing varying electric controls in each conductor through a succession of definite periods in a common time cycle and for causing the periods of a particular electric control in the wires of a pair to be equal in time while maintaining the midpoints of said equal periods displaced by 180 degrees of the time cycle as between the conductors of each pair, but in synchronism at their midpoint and for different periods as between different pairs, means at each station responsive to said electric controls in any conductor for displaying "go" and "stop" signals for through and cross traffic in periods of a routine traffic cycle in accordance with the periods of said electric controls, and means at each station for connecting said signal display means selectively with certain of said conductors whereby the signals may be displayed for either a longer or a shorter "go" or "stop" period of a traffic cycle.

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