Sept. 27, 1966 J. L. BARKER 3,275,984

TRAFFIC MONITORING AND CONTROL SYSTEM

Original Filed Feb. 5, 1959

3 Sheets-Sheet 1

FIG. 1

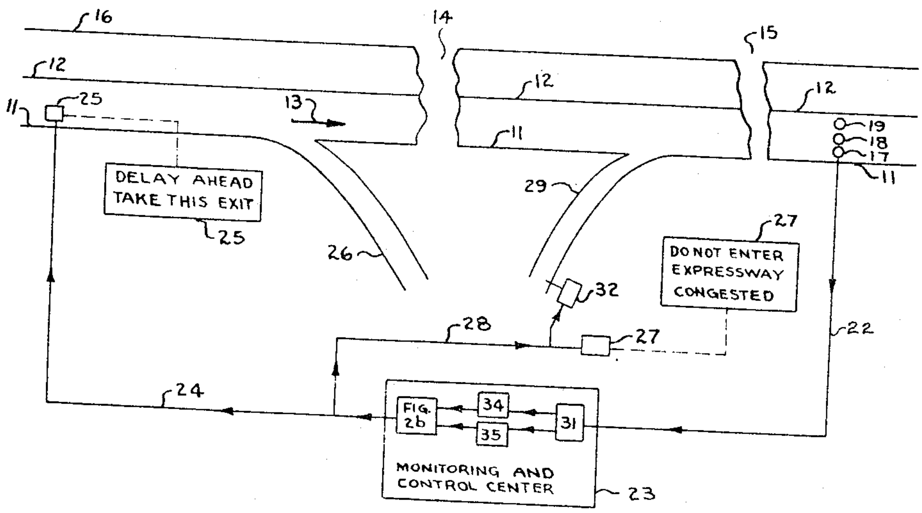
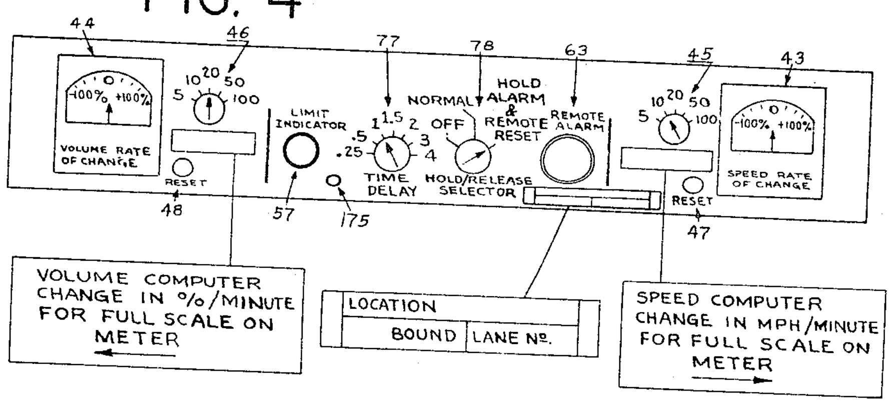


FIG. 4



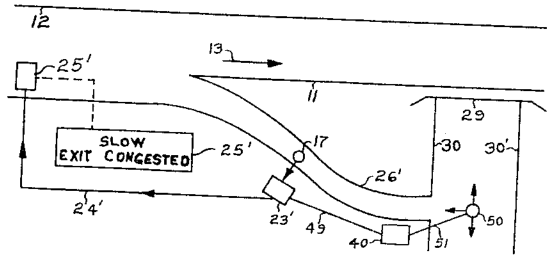


FIG. 5

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TRAFFIC MONITORING AND CONTROL SYSTEM

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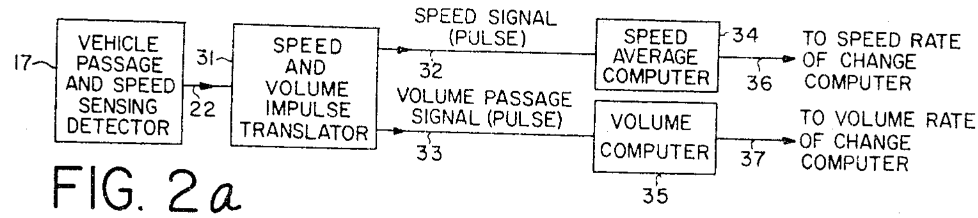


FIG. 2a

FIG. 2b

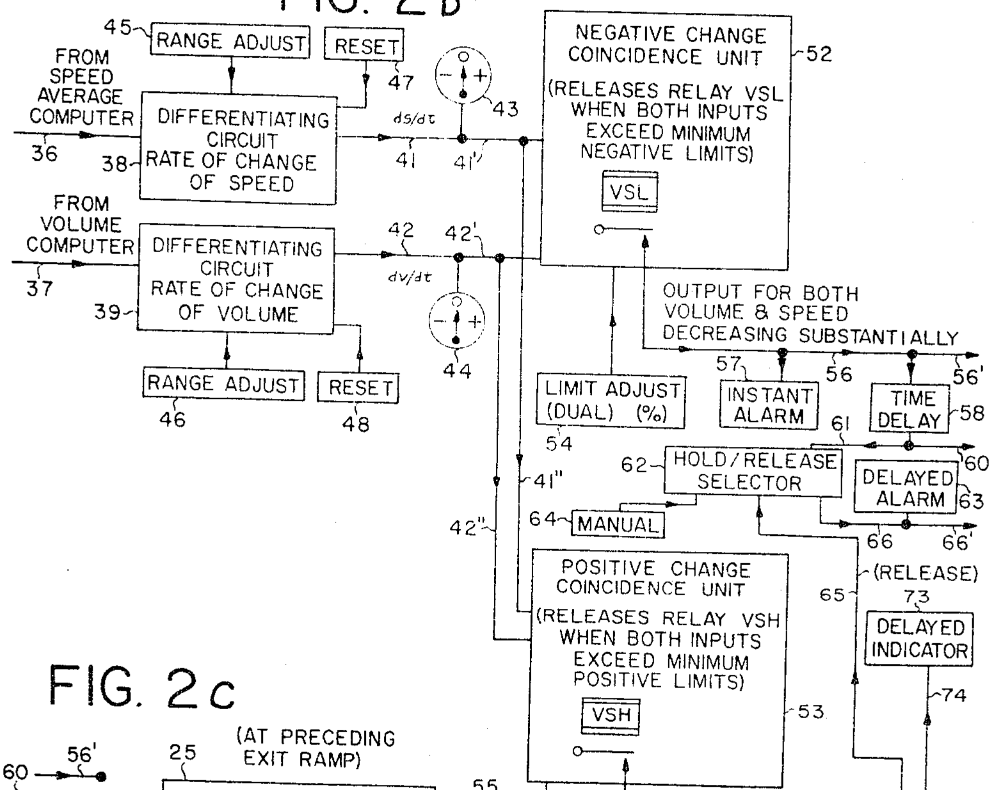
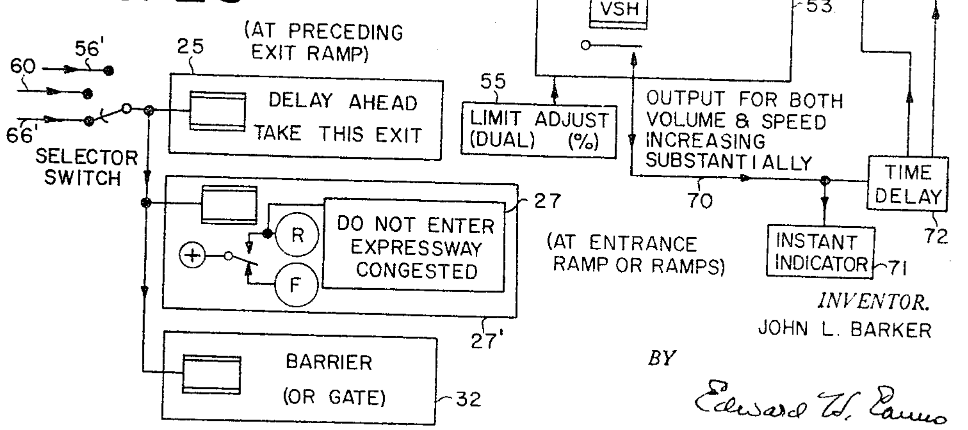


FIG. 2c



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3 Sheets-Sheet 3

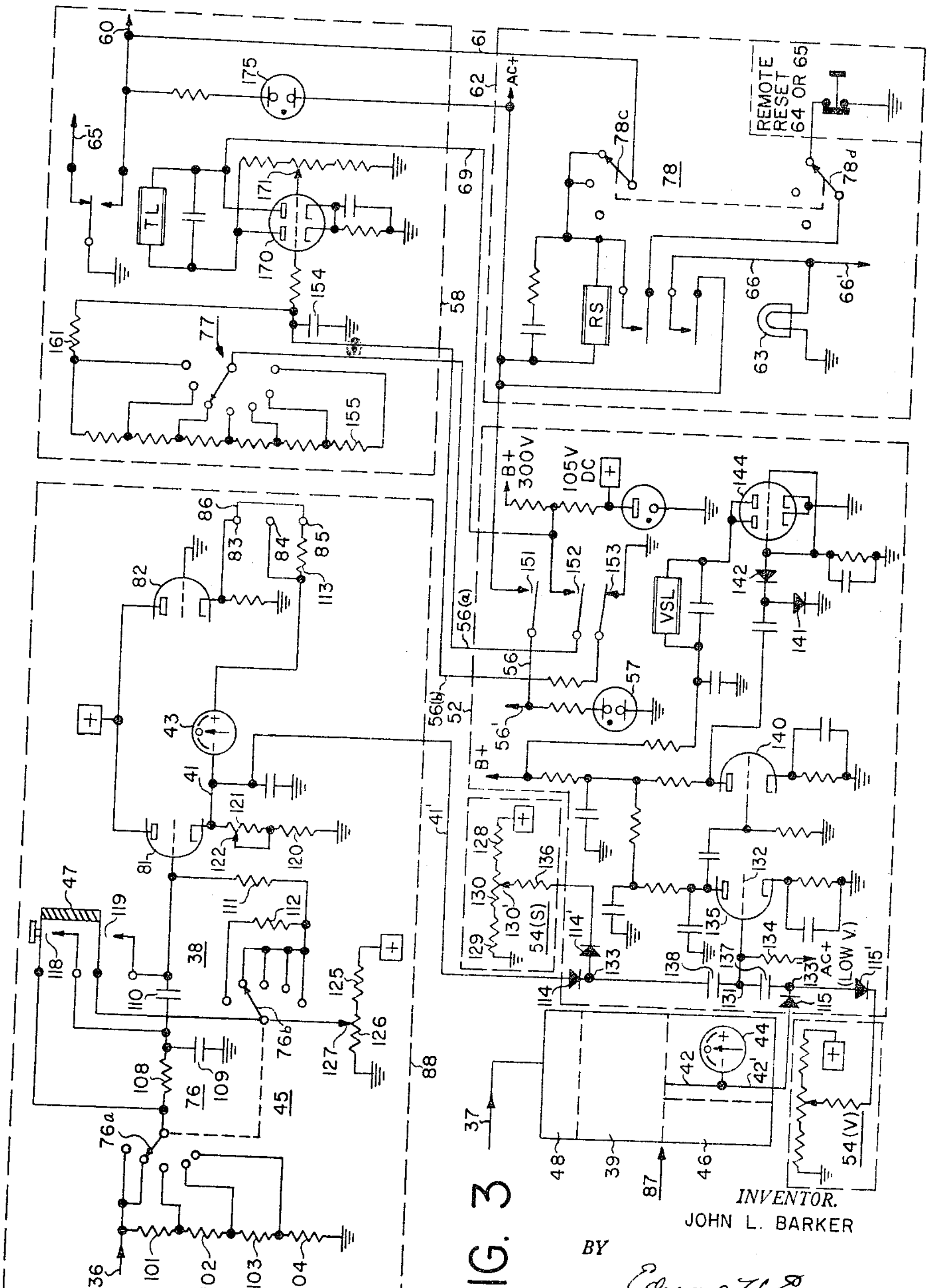

FIG. 3

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TRAFFIC MONITORING AND CONTROL SYSTEM

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Continuation of application Ser. No. 791,460, Feb. 5, 1959, now Patent No. 3,237,154, dated Feb. 22, 1966. This application May 27, 1965, Ser. No. 459,284
12 Claims. (Cl. 340—31)

This invention relates to a system for monitoring traffic and responding to particular changes in conditions of traffic flow such as volume and speed, to indicate such changes, and to operate alarm devices and remote changeable signs, signals or other devices to guide or control traffic in relation to entrance to and exit from highways or expressways, or to one or more of these features.

This application is a continuation of my copending patent application, Serial No. 791,460, filed February 5, 1959, now U.S. Patent 3,237,154, issued February 22, 1966. The present application is directed more particularly to certain aspects of the subject matter disclosed in said parent application but not claimed in said Patent 3,237,154, as more fully set forth below.

Certain aspects of the disclosure of the present application, particularly relating to response to concurrent rates of change in traffic volume and traffic speed of predetermined amounts and directions of change, for example, are repeated to some extent from said parent application for convenience of reference and understanding in the present application, but are claimed in said Patent 3,237,154. Reference may be had to the aforesaid patent for further features and details of response to concurrent changes in speed and volume.

The present application is more particularly directed to aspects of the invention relating to sensing or determining and responding to the rate of change of a traffic flow characteristic such as traffic volume or traffic speed alone.

In a preferred form of one aspect of the invention, the present application provides means for sensing vehicles in a stream of traffic and producing an electrical signal, such as a voltage, representing a varying characteristic of traffic flow as averaged over a period of time or number of vehicles, producing therefrom a further electrical signal or voltage as an output representative of the rate of change of the first electrical signal, and representative of the rate of change of said traffic flow characteristic. Such output or a predetermined such output may be used for operating an indicator, alarm or traffic control device. In one preferred form such further electrical signal (for rate of change) is compared with a reference to provide an output in response to such further electrical signal having a predetermined amount or value representing a rate of change of predetermined amount and direction, which output may be used to operate the indicator, alarm, or traffic control device.

From further aspects, the invention relates to electrical apparatus for determining the rate of change of traffic volume and the rate of change of traffic speed and indicating or responding to selected such changes of predetermined degree, which may be adjustable. Thus the apparatus may be arranged to respond to decreasing traffic volume alone, or to decreasing speed alone, or to increasing speed or volume, or to a combination of increasing speed and increasing volume, or to a combination of increasing speed and decreasing volume, or to a combination of decreasing speed and increasing volume, or to concurrent decrease in both speed and volume, where response to or indication of such individual conditions or combination of conditions is desired.

In its preferred form, the present apparatus senses the traffic changes by deriving the rate of change of the average speed and/or the rate of change of the traffic volume.

Some aspects of the invention may be applicable to fields other than traffic, as in the determination of rate of change of a varying average over an adjustable range or beyond a selectable limit or critical value.

The great increase in the volume of vehicular traffic on streets and highways in recent years has resulted in many of such roads becoming overloaded or congested at times despite the continued building of new road facilities. In this connection, the term "traffic volume" is used in its generally accepted sense of the rate of traffic flow past a given point in number of vehicles per unit of time, such as vehicles per hour for example.

Modern high type traffic road facilities such as expressways, freeways, parkways and the like, generally limit access to widely spaced entrance ramps and exit ramps, avoid cross traffic by over-passes or under-passes, and provide multiple traffic lanes and easy curves and are designed for heavy traffic at relatively high speeds. Such high type highway facilities are very costly to build and are involved in the transport of essential goods and the transport of people to and from work, in many cases, as well as for pleasure.

Even in the best of such high type facilities, most or all of the roadway may be blocked in one direction by a major accident, and in periods of heavy traffic volume, a relatively small accident or minor breakdown in one lane or some local change in road or visibility conditions may so impede traffic that the flow of traffic is suddenly slowed down to a very low level and the effective capacity of the roadway is so reduced that long lines of traffic may accumulate with large numbers of vehicles stopped or waves of stopping and starting and moving at very low speeds may move back along the line of traffic.

The accumulation of such stopped or very slow moving traffic, may extend back several miles from the obstruction before traffic authorities are aware of the situation, and in many cases, because of hills or curves in the road, other drivers approaching the trailing end of the line of slow moving traffic will not realize the situation until they have passed a possible exit or other alternate route.

Certain sections of the roadway may be more susceptible to such conditions than others, but in any event, it has been a serious problem to notify traffic authorities or the traffic itself, or both, of such congested traffic conditions as soon as possible, both from the viewpoint of getting aid to accident victims promptly and from the viewpoint of expediting traffic and diverting it if necessary as soon as possible.

The sensing of sustained low speed alone below a preselected critical speed as by a succession of such speeds of vehicles, may give indication of traffic obstruction or the like in some instances. Apparatus for responding to a succession of below critical low speeds of vehicles in traffic, and operating an indicating device or alarm device therefrom, is disclosed and claimed in a copending patent application Serial Number 777,711, entitled, Traffic Speed Monitor, filed December 2, 1958, now U.S. Patent 3,024,443, issued March 6, 1962, in which I am a joint inventor with Bernard J. Midlock. Such apparatus may be used as a means for determining sustained low speeds in certain traffic control systems as some aspects of the present invention as appears below.

However, speed alone may also decrease with increasing traffic volume before the latter reaches a critical level approximating the practical capacity of the road. It is known to traffic authorities that if more traffic then arrives on the road tending to exceed this critical level, the actual traffic volume and speed will both drop sharply, and the effective capacity will be much reduced. Environmental factors also such as weather and road conditions such as ice, snow, wet pavement or fog will often cause marked shifts in a critical level of volume or of speed.

Thus, the impedance or congestion of traffic popularly known as a "traffic jam," may arise because of an accident, road conditions, or other factors at moderate or relatively low traffic volume as well as arising at times of high traffic volume, and the problem has been to identify automatically by some means the congestion or substantial impedance of traffic over a wide range of traffic volumes and speeds.

Most people are familiar with the fluctuations normally encountered in normal traffic flow over any given time period, and thus decreasing traffic volume alone would not necessarily indicate traffic congestion.

It is an object of the invention to determine and indicate the rate of change of traffic volume with respect to time and the rate of change of traffic speed with respect to time in relation to running averages of such volume and speed.

It is another object of the invention to sense a predetermined minimum or threshold value of rate of change of traffic volume or traffic speed in a predetermined direction of change for indicating, alarm or control purposes.

It is a further object of the invention to provide a method or means of traffic control by sensing restriction of traffic flow by sensing substantial reduction in traffic speed and/or traffic volume at a point on a roadway and to operate or control a traffic sign and/or signal to warn of and/or to relieve such restriction.

It is also an object of the invention to provide a method or means for monitoring traffic along a highway or expressway by sampling traffic speed and traffic volume at one or more points thereon, computing running averages of traffic speed and traffic volume, and determining therefrom at a remote or central monitoring point the rate of change of speed and the rate of change of volume over a scale from negative to positive values, and providing indications or alarms or both at such remote point.

Other objects of the invention may be apparent in the following description and appended claims with reference to the accompanying drawings in which:

FIG. 1 shows a plan view of spaced sections of a roadway such as an expressway or freeway, illustrating one application of speed and volume change sensing equipment for remote monitoring and control of traffic signs and related devices.

FIG. 2, comprising the SUB-FIGURES 2*a*, 2*b*, and 2*c*, illustrates in block diagram form a preferred form of traffic monitoring and control system for sensing particular changes in traffic speed and volume and responding to such changes.

FIG. 3 shows in schematic form a preferred circuit diagram of a Volume and Speed Rate of Change Unit appearing in part FIG. 2*b* of FIG. 2 and of certain associated alarm and control products of part FIG. 2*c* of FIG. 2.

FIG. 4 illustrates the indicating, adjustment and control panel of a preferred form of Volume and Speed Rate of Change Unit for responding to concurrently decreasing volume and speed, of the type shown in FIG. 2*b* and FIG. 3.

FIG. 5 shows another form of exit ramp arrangement employing detection of traffic congestion on the ramp to operate a warning sign on the expressway approaching the ramp, or other traffic control device.

Referring now to FIG. 1, there is shown a part of an expressway or freeway of the usual divided roadway type, of which only about one half is shown for convenience of illustration. The outer and inner edges **11** and **12** of the roadway for the one direction of traffic indicated by the arrow **13** extend through the three sections of roadway indicated as spaced some distance apart along the roadway by the breaks **14** and **15**, introduced merely for convenience in the drawing. The central divider strip is indicated by the edges **12** and **16**, the latter edge also representing the inner edge of the companion roadway (not shown) for the opposite direction of traffic.

A detector **17** for sensing vehicle passage and speed is illustrated at the right side of the FIG. 1 at a desired point for sampling vehicular traffic passing along the roadway in one of traffic lanes on the roadway. The detector **17** is illustrated over the outer lane, for example, and may be of the type known as Model RS1 Radar Speed and Impulse Unit, manufactured by Automatic Signal Division of Eastern Industries, Incorporated, the assignee of the present application for patent, and more fully described and illustrated in my copending application Serial Number 732,248, filed May 1, 1958, for Traffic Monitoring System, now U.S. Patent 3,059,232 issued October 16, 1962.

This speed and passage detector **17** develops an electrical signal representing passage of a vehicle and its speed in the associated traffic lane, this signal being transmitted by a two-wire line **22**, such as a telephone line, for example, to the remote monitoring and control center **23**, where this signal is translated into separate channels for computing traffic volume and traffic speed on a running average basis, and particular rates of change of speed and volume are sensed for indicating and alarm purposes and to control automatic or changeable signs or other control devices, as more fully explained later herein. The blocks within block **23** are numbered to correspond to their respective counterparts in FIGS. 2*a* and 2*b*, for example.

The monitoring and control center **23** may control via line **24** an electrically operated changeable sign **25**, for example, in advance of exit ramp **26** to direct traffic to this exit in case of sensing traffic congestion or impending congestion at the sampling point by a combination of decreasing average speed and decreasing volume. Similarly, the center **23** may operate another changeable sign **27** via line **28** to direct traffic from entering the expressway on entrance ramp **29**. A traffic barrier or gate **32** of the remotely controlled or automatic type may be operated as a supplement to sign **27**, if desired.

Other speed and passage sensing directors may be located over other lanes as indicated by such detectors **18** and **19**. These may be in addition to detector **17** or one or the other may be connected to the remote center **23** instead of detector **17**. If only one detector such as **17** is used, it will be in whichever lane is most representative of changes in traffic volume and speed on the roadway, particularly in case of congested traffic conditions.

For continuous monitoring on all lanes, the several detectors **17, 18** and **19** would be individually connected to the monitoring center **23** by additional channels or lines not shown, and the center **23** would have individual translating, computing and rate of change response units preferably, although their outputs might be combined for alarm control circuitry.

FIGS. 2*a*, 2*b* and 2*c* are arranged to be connected together, as indicated by the corresponding numbered lines and together represent a complete traffic speed and volume sensing and concurrent rates of change sensing, indicating and control system, although certain features may be omitted in some instances, as desired. For example, the sign or gate control featured on FIG. 2*c* may be omitted if it is desired to use the monitoring, indicating or alarm features as one aspect of the invention, as in FIGS. 2*a* plus 2*b*, or as in FIG. 2*b*, where average speed and volume inputs are available.

FIG. 2*a* shows in block diagram form the vehicle passage and speed sensing detector **17** and its connection **22** to a speed and impulse translator **31**, which is preferably, but not necessarily, located in the remote monitoring and control center **23** of FIG. 1. This translator separates the combined speed and passage signal into its speed pulse or signal on line **32** and passage pulse or signal on line **33**. This translator **31** is more fully disclosed in my copending application Serial Number 732,248, above referred to, and its details are not material to the present invention.

The speed signal pulses from individual passing vehicles are in the form of a direct current voltage substantially proportional to speed and are fed into the speed average computer **34** which is also disclosed in my said copending application, Serial Number 732,248, and provides an electrical voltage output on line **36** representing a running average of the latest, adjustably predetermined number of vehicles.

The volume or passage pulses for the individual vehicles are of the voltage change type, as provided by operation of a relay contact, for example, and are fed to the volume computer **35**, which is also disclosed in my said copending application, Serial Number 732,248. This volume computer provides an output voltage on line **37**, representative of a running average of the average number of vehicles passing the sampling point per unit of time over the latest adjustably predetermined time period, which may be of the order of several minutes, for example.

Thus the details of the components and connections of FIG. 2*a* are all the subject of prior patent applications, and are illustrated here as examples of means for sensing vehicle passing and speed and providing an average speed output signal voltage and a traffic volume output voltage which also serves as an averaged value as contrasted with an instantaneous value.

The respective output voltages representing average speed on line **36** and average volume on line **37** serve as inputs to differentiating circuits **38** and **39** respectively, in FIG. 2*b*, to determine the rate of change of speed as a voltage output abbreviated ds/dt on line **41** and the rate of change of volume as a voltage output abbreviated dv/dt on line **42**. These rates of change are indicated on the respective meters **43** and **44**, each of which is calibrated in percent between negative and positive scale limits with a center zero. Different ratios of the rate of change to the scale and to the output voltage on line **41** or on line **42** respectively may be obtained by the range adjustments indicated at **45** and **46** for the respective rate circuits. Similarly, the blocks **47** and **48** indicate resets for the respective rate circuits. These may be manually operated or by remote controlled relays, for example, to reset the rate circuits to zero, if desired.

The rate output lines **41** and **42** extend as lines **41′** and **42′** respectively and feed into the negative change coincidence unit **52** and may also extend into a positive change coincidence unit **53**, on lines **41″** and **42″** as branches of lines **41′** and **42′** respectively.

These change response units operate as more fully disclosed in connection with the circuit diagram of FIG. 3, but serve to respond to concurrent rates of change beyond predetermined minimum limits in the stated direction, with such predetermined limits for speed and volume rates individually adjustable as indicated by the block **54** for the negative change response unit **52** and by the block **55** for the positive change response unit **53**. Considering further, the negative change coincidence unit **52**, it will be noted that it is indicated that this responds to concurrent negative values of rates of change of both speed and volume by releasing relay VSL to close its associated contacts to provide an output on line **56**. These relay contacts are of the normally closed type, i.e., they are closed only when the relay is deenergized, but these contacts are normally held open by energization of the relay through the action of the associated circuit shown in FIG. 3, in absence of concurrent negative rates, characterizing decreasing speed and volume, beyond the limits set by the dual individual adjustments **54**.

The output line **56** is connected by a branch to an instantaneous indicator or alarm **57**, and by another branch to a time delay device **58**, which after a predetermined time of persistence of its input provides an output to line **60** and also via line **61** to the "Hold/Release Selector" **62**. The output on line **60** may be used for generation of other devices, such as remotely located indicators, alarms, or traffic warning or control signs or devices.

The hold-release selector **62**, as shown more fully in

FIG. 3, controls the action of the delayed alarm or indicator **63** and the associated output line **66′** by determining whether the delayed alarm **63** and the output on line **66′** will be maintained only as long as the concurrent negative change indicating output on line **56** continues or will be held or maintained after such indicating output on line **56** ends, as when the traffic volume and speed are no longer decreasing sufficiently.

In the hold condition, the output on line **66** and **66′** and the operation of the alarm or indicator **63** is sustained until release by manual switching of this selector **62** to a release or non-hold position, or by manual operation of a remote release switch **64**, or by automatic remote release via line **65**, for example. Any other or remote devices which may be connected to line **66′** will also be held in activated condition by the hold-release selector **62** when the latter is set to the hold condition and until released in a manner similar to that described above in relation to delayed alarm or indicator **63**.

The other or remote devices may alternatively be connected to line **60**, so that they will release automatically upon ending of output on line **56**, and consequent reset of the time delay unit **58**. The latter provides its time delay between the start of active output on line **56** and the start of output on lines **60** and **61**, and after such output on line **56** has persisted for such time period, but this unit **58** is immediately resettable to terminate its output on **60**, **61** if there is any interruption of output on line **56**, which serves as the input to this time delay unit **58**. This unit **58** acts as a slow-operate, quick release time delay relay.

The part of FIG. 2*b* described above corresponds in general to the circuit diagram of FIG. 3 presenting a speed and volume rate of change unit which responds to concurrent negative rates of change exceeding the limits set. There is also shown in FIG. 2*b* a speed and volume rate of change unit for responding to concurrent positive rates of change exceeding set limits as briefly mentioned above.

The latter unit is shown in the lower right part of FIG. 2*b*. Thus branches **41″** and **42″** of the rate of change output lines for speed and volume respectively extend downward to feed these outputs into a positive change coincidence unit **53**. This unit **53** is the same as the corresponding negative change coincidence unit **52** above except that the diodes shown in FIG. 3 associated with the input circuits **41″** and **42″** would be reversed in unit **53** to respond to positive coincidence or concurrence of inputs instead of negative concurrence of inputs, and in connection with unit **53** the limits adjustment **55** for response would be set as desired for the minimum positive rates of change to which it is desired to respond.

The concurrence of positive rates of change of both volume and speed beyond the set limits releases the relay VSH in unit **53** in the same manner as concurrence of negative rates of change releases the corresponding relay VSL in unit **52**. The release of relay VSH closes its contact shown in FIG. 2*b* to provide an output on line **70** in response to concurrence of positive rates of changes beyond the limits set by adjustor **55** and thus representing concurrent substantial increase in both traffic volume and speed.

This output on line **70** operates an instantaneous indicator **71** and a time delay untit **72** which, after a sufficiently long continued such output on line **70**, will operate the delayed indicator **73** via line **74**. A further output line **65** is shown from the time delay unit **72** and serves as an automatic remote reset or release of any previously set up delayed alarm **63** or associated devices which may be held operated after initial actuation by the time delay unit **58** and the hold-release selector **62** when the latter is set to its "Hold-Remote Reset" position as indicated on the control panel of the assembly shown in one preferred form in FIG. 4, for example but without limitation thereto.

The two outputs **74** and **65** from delay unit **72** are shown to illustrate both make contact and break contact operations, since the delayed indicator **73** and other such devices would ordinarily operate from make contacts and since the reset or release through the hold-release selector is illustrated in the circuit diagram as of the series type employing the opening at least momentarily of a normally closed contact, such as shown in the box marked "remote reset" in the lower right corner of FIG. 3. This contact may be of the manually operated push-button or momentary opened contact type or may be a break contact on the output relay of the time delay unit, represented by the designation "**64** or **65**." A corresponding such break contact **65'** is illustrated on the output relay TL in the time delay unit **58** of FIG. 3 for example, and it will be understood that a corresponding break contact on the output relay (not shown) may be provided in time delay relay **72**. It will be appreciated that electrical devices may readily be arranged to operate from either make contacts or from break contacts as desired, and the circuit arrangements are for purposes of illustration.

It will also be understood that other indicator, alarm or control devices may be connected to line **74** to be operated thereby, and that if desired to use the positive change unit **53** as an independent indication of positive change coincidence instead of for reset of the negative change coincidence alarm, the positive change may have a hold-release selector for control of indicator **73** or the like for example.

FIG. 2*c* illustrates in more detail several types of traffic control or warning devices which may be operated by one of the outputs **56'**, **60** or **66'** derived from the output **56** of the negative change coincidence unit **52**. Thus in FIG. 2*c* all three lines **56'**, **60** and **66'** are shown with a switch for selecting among them for the type of control desired. The line **56'** would provide instantaneous control, the line **60** would provide delayed control and the line **66'** would provide delayed control subject to the action of the hold-release selector **62**. The switch in FIG. 2*c* is shown in position connecting the latter line **66'** to operate the electrical illuminated or changeable signs **25** and **27**, as well as the barrier or gate **32**, these reference numbers corresponding to the same devices in FIG. 1.

It will be noted in FIG. 2*c* that sign **27** is indicated as part of a larger sign and signal assembly, including a red or stop signal R which is operated with the sign, and a cautionary or flashing signal F operated when the sign is not operated, the operation or non-operation being under the control of the relay indicated. It will be appreciated that these signs and other devices are illustrative and other forms may be used or the signals or some of the other features might be omitted in some instances.

The circuit diagram comprising FIG. 3 illustrates a preferred form of electrical apparatus corresponding to the block diagram of FIG. 2*b*, but illustrating particularly the upper part of FIG. 2*b* involving response to concurrently decreasing speed and volume and the associated alarm circuitry, without the positive change response unit **53** and its associated indicators **71** and **73** and time delay unit **72**.

The positive change response unit **53** and such associated elements of FIG. 2*b* relate to the response to concurrently increasing speed and volume, and may be used alone in some instances as a suppliement to the concurrent decrease response part above if desired in accordance with the types of response desired for the intended use.

As mentioned above, however, if the rectifier pairs associated with input lines **41'** and **42'** at the left in the broken line **52** of FIG. 3 are all reversed from the manner shown, and the relay designation VSL changed VSH, then the part of FIG. 3 designated **52** will serve to illustrate the positive change response unit **53**, it being assumed in such case that the limit or threshold adjustments **54** or **54**(*s*) and **54**(*v*) also will be set to the desired higher positive voltage value equivalent to a meter reading substantially above zero on its scale, which zero in turn may be equivalent to some convenient intermediate voltage value on a scale of positive voltage values of the same polarity, as positive for example in the preferred form illustrated.

Operation of the speed rate of change measuring circuit, including differentiating circuit **38**, range adjust **45** and reset **47** will now be described more fully with reference to FIG. 3. It should be noted that the volume rate of change measuring circuit is an exact duplicate of the speed rate of change measuring circuit, therefore the circuitry details of the volume rate of change measuring circuit are not shown within the block **87**, but the detailed circuitry above in the corresponding speed rate of change measuring block **88** serves to illustrate both. The procedure of calibration and setting as will be discussed below, as well as operation of the circuitry, apply to both the speed rate of change measuring circuit and the volume rate of change measuring circuit.

Input speed information, in the form of a direct current voltage, from zero, with respect to ground, to plus 100 volts above ground for example, is applied via lead **36**, from the speed averaging computer, through a potential divider including resistors **101**, **102**, **103** and **104** to ground. The input applied via lead **36** represents the detected running average vehicle speed of the desired last number of vehicles of from zero to 100 miles per hour.

Input volume information, in the form of a direct current voltage, from zero, with respect to ground, to plus 100 volts above ground for example, is applied via lead **37** from the volume computer to a similar potential divider, not shown, in the circuitry of the volume rate of change measuring circuit **87**.

The input applied via lead **37** represents the running average volume of traffic with 100 volts representing the upper end of the range of traffic volume anticipated, for example. This may for example, be of the order of 2000 vehicles per hour for a typical traffic lane in a roadway having free running traffic, although some lanes might have a lower volume corresponding to the 100 volts. For convenience 100 volts are considered to equal 100% for the upper end of the desired range of traffic volume.

A multiposition ganged selector switch **76**, including sections **76*a*** and **76*b***, in conjunction with the associated resistors comprise the "range adjust" **45**, which serves to adjust the sensitivity of the rate measuring circuit, that is, the speed change per unit of time to produce full scale reading on the rate of change meter **43**.

A corresponding selector switch and associated circuitry serve as "range adjust" **46** for the control of sensitivity of the volume rate measuring circuit **39**.

The selector switch **76** of range adjustor **45** is illustrated in FIGS. 3 and 4 in its second position, which may for example correspond to a rate of change of speed of 10 miles per hour per minute for a 100% indication on the meter **43**. The rate of change of speed may be expressed as m.p.h. per minute for example for convenience and as a reminder that this is the rate of change of the average speed and is not employed in the frequently used sense of acceleration.

The scale of values of range adjustor **45** shown in FIG. 4 are given as one example of such values in m.p.h. change per minute, but without limitation thereto.

With range adjustor **45** so set for **10** m.p.h. per minute the speed rate of change meter **43** will indicate minus 100% for a decrease in the running average speed of 10 m.p.h. per minute, and will indicate plus 100% for an increase in the running average speed of 10 m.p.h. per minute, the meter having a central zero indication for no change in speed and being linear for intermediate readings as well.

The signal from selector switch section **76*a*** is channeled through resistor **108** to capacitor **109**, the combination of which serves as a smoothing filter for the signal and to substantially eliminate any sharp changes in voltage that may occur in the signal due to any A.C. pickup or extraneous noise.

The filtered signal is fed through the differentiating network **38** including capacitor **110** and resistor **111**, with the differentiated voltage appearing across resistor **111**. Selector switch section **76*b*** is ganged to section **76*a*** as previously described and provides a 100% increase in the sensitivity of the unit in the maximum sensitivity or top position as compared to the second position by connection of resistor **112** in series with resistor **111**, and resistor **112** is shunted out in all positions except the top position.

The differentiated input voltage, corresponding to the rate of change of the speed is applied to the grid of triode **81**. Triode sections **81** and **82** are a balanced type voltmeter through which is obtained stability for accurate reading of low voltages. The meter **43** is connected via resistor **113** between the cathodes of triode sections **81** and **82**. It will be noted that terminal **85** is connected to terminal **83** via line **86**. This connection includes resistor **113** in the circuit between the two cathodes of the two triodes.

It may be desired to by-pass the resistor **113** via terminal **84** and to connect a recorder or remote meter between terminal **84** and terminal **83**. In such case the resistance of such recorder or remote meter should approximate the value of resistor **113** which may be of the order of 2000 ohms, for example, to maintain the calibration of the unit.

The differentiated signal is available in voltage form at the cathode of triode **81** and is fed via line **41** and **41′** to crystal rectifier **114** in the negative change coincidence unit **52**.

The differentiating circuit **38** may be reset by operation of reset **47**, which is illustrated as a push-button controlling contacts **118** and **119**. Closure of contact **118** shunts out the input series resistance **108** in the filter network to provide a low impedance path for rapidly charging capacitors **109** and **110** while contact **119** shunts out the resistor **111** to provide another low impedance path. The combined low impedance paths insure that capacitor **110** rapidly assumes the potential of the input voltage from the speed averaging computer as applied via line **36** as tapped by switch **76*a***, and thereby, upon release of the reset pushbutton **47**, the unit will read the differentiated input signal from this point on.

Calibration of meter **43** is made by adjustment of two potential dividers, one potential divider including potentiometer **121** and resistor **120** between the cathode of triode **81** and ground, the second potential divider including resistor **125** and potentiometer **126** between the D.C. supply and ground. With tap **127** adjusted to its ground extremity the minus 100% rate indication is calibrated by adjustment of tap **122** on potentiometer **121**. The zero or center point may then be set by adjustment of tap **127** on potentiometer **126**. The latter adjustment in effect determines the voltage about which the circuit will differentiate the input signal. Calibration of the circuit would be made with the reset button **47** held closed. After calibration is completed, the reset button **47** serves to reestablish a proper reading more quickly after any change in adjustment **45** for example or when the unit is first turned on.

The output of the differentiating circuit is biased in a positive direction with respect to ground by the potentiometer **126–127**, and is applied to the grid of the cathode follower triode **81**, and the output of this tube on line **41** is always positive above ground for all indications of meter **43** from minus 100% reading through zero to plus 100% reading of rate of change.

The differentiated signal on line **41** is applied via lead **41′** to crystal rectifier **114** to control the impedance at junction **133** with respect to ground in cooperation with similar rectifier **114′** and the "limit adjust" **54(*s*)**, and thus to provide a threshold control for operation of the amplifier tube **135** in response to a differentiated signal of sufficiently low positive D.C. voltage, corresponding to a sufficiently large negative rate of change of speed, as set by the threshold or limit adjuster **54(*s*)**, as more fully described below in connection with the clamping and unclamping of the input to tube **135** under control of the impedance at junction **133**.

FIG. 2*b* illustrates in block form a "limit adjust (dual) (%)" **54**. This illustrates, functionally, two limit adjusting units, shown in FIG. 3: **54(*s*)** associated with rate of change of speed and **54(*v*)** associated with rate of change of volume.

The limit adjusting units **54(*s*)** and **54(*v*)** are similar to each other and limit adjust **54(*s*)** is in the form of a potential divider including resistors **128** and **129** in series with potentiometer **130** between a positive D.C. supply and ground, and this limit adjust **54(*s*)** serves to set the desired limit or threshold of negative rate of change of speed required for operation of the negative change coincidence unit.

To set the desired decrease as a limit on the limit adjust **54(*s*)**, the potentiometer arm **130′** may be adjusted so that the positive voltage between arm **130′** and ground is of the same value as the positive voltage between line **41** and ground when the meter **43** reads a value of minus 10%, for example. This setting would provide one of the two inputs required for operation of the negative change coincidence unit when a rate of decrease of 10% or more occurs in the average speed.

The negative change coincidence unit provides an indication when both the average speed decreases at a rate exceeding the preset limit as adjusted by the limit adjust **54(*s*)** and the average volume decreases at a rate exceeding the preset limit as adjusted by the limit adjust **54(*v*)**. The individual rates of decrease, represented in a percentage, will appear on the respective meters **43** and **44**, as for example minus 10%. The speed and volume rate of change signals for operation of the negative change coincidence gate are applied on leads **41′** and **42′** to rectifiers **114** and **114′** and to rectifiers **115** and **15′** respectively. When the positive voltage applied via lead **41′** at point **133** is less than the positive voltage applied via arm **130′** of limit adjust **54(*s*)** and the positive voltage applied via lead **42′** at point **133′** is less than the positive voltage applied via the arm of the potentiometer of limit adjust **54(*v*)**, an unclamping of the grid **132** occurs and the negative change coincidence unit produces an output.

Operation of the clamping action at the input circuit to the negative change coincidence unit will now be explained more fully with respect to the rate of change of speed circuit, which operation is similar to that of the rate of change of volume circuit.

Sixty cycle alternating current (A.C.) of a very low value, 3 volts for example, is connected via high resistance **134** to the grid **132** of triode **135**. With the negative change coincidence unit held clamped, the A.C. is prevented from acting on the grid **132** by capacitor **138**, in combination with diodes **114** and **114′** and/or by capacitor **137**, in combination with diodes **115** and **115′**. With the voltage at lead **41′** of a higher value than the voltage at the arm **130′** of potentiometer **130**, current flows through diodes **114** and **114′** of sufficient magnitude to hold the voltage at junction **133**. This effectively provides an A.C. ground at junction **133** and via capacitor **138** to the grid **132**.

It has been found that satisfactory operation is provided with the following typical values of components associated with the circuits producing the clamping, but without limitation to such values; resistance **134**, 10 megohms; capacitor **138**, 1 microfarad; resistance **128**, 82,000 ohms; resistance 129, 3000 ohms; potentiometer 130, 3000 ohms; resistance 136, 100,000 ohms.

Resistors 128, 129 may be reduced or omitted and the value of 130 increased if desired to extend the range of adjustment. Similarly the fixed resistors in limit adjust 54(v) may also be reduced or omitted if so desired.

Thus the output voltage, via leads 41′ and 42′ of the rate of change of speed circuit and the rate of change of volume circuit respectively, must fall below the voltage set on the respective limit adjust circuits 54(s) and 54(v) in order that the unclamping effect occur and thus provide a clipped A.C. or a chopped D.C. for amplification by the tubes 135 and 140.

This action results from the change from low impedance to high impedance at both junctions 133 and 133′. The increased impedance in the A.C. circuit reduces the current and consequent voltage drop across resistor 134 and allows the A.C. to act on the grid 132.

The applied 60 cycle A.C. is amplified by two high gain stages of conventional resistance capacity coupled amplifiers. The amplified A.C. is then rectified at the anode circuit of triode 140 by means of diode doubler combination 141 and 142. This combination produces a negative D.C. voltage (with respect to ground), which voltage is applied to the parallel connected grids of dual triode 144, which is connected to react as one tube. The applied negative voltage on the grids of dual triode 144 increases the bias of the triode to cut-off. The triode, which is in the energizing circuit for relay VSL materially reduces the plate current and deenergizes relay VSL.

This combination of a high gain amplifier and the clamping-unclamping action described above on the A.C. signal at its input and a rectified output operating the control circuit for relay VSL, provides the sensitivity required to sense the small D.C. rate signals with a high degree of accuracy at the threshold points, and to respond only beyond the desired threshold or thresholds as set by the limit adjustors.

With both inputs from 41′ and 42′ sufficient for unclamping, relay VSL is deenergized and closes its contacts 151 and 152 and opens its contact 153. Closure of contact 151 supplies A.C. power, of the order of 110 volts for example, to the "instant alarm" 57 and to output lead 56′. Closure of contact 152 supplies D.C. positive power to time delay unit 58, while the opening of contact 153 opens the discharge circuit to ground for the timing capacitor 154 in the time delay unit.

The time delay unit, illustrated in the circuit diagram in FIG. 3, blocked off by a broken line box 58 includes a timer which may, by way of example, be of the type illustrated, or may be any conventional timer or delay action relay. The timer illustrated in FIG. 3, in time delay unit 58, is one type of electronic timer that may be employed in the time delay unit. The illustrated timer is of the type disclosed and claimed by Peter C. Brockett in his copending application Serial Number 677,993 filed August 13, 1957, under the name, Electronic Timing Circuit, now U.S. Patent 2,964,625 and assigned to the assignee of the present invention.

Normally, with relay VSL energized, contact 153 is closed and supplied a ground connection to the upper side of timing capacitor 154 to keep the capacitor substantially at ground potential. This maintains the grid in the left side of triode 170 at ground potential and keeps the left side of the triode 170 biased to cut off while the right side of triode 170 is conducting.

The switch 77 is a multiposition selector switch for selection, as desired, of one or more of the resistors 155 to 161 for inclusion in the charging circuit between the D.C. supply and timing capacitor 154, to determine the timing interval.

Upon completion of the charging circuit and opening of the ground connection to the upper side of capacitor 154 the charge on the capacitor 154 is increased and the potential applied to the grid in the left side of tube 170 is likewise increased.

When the potential applied to the grid in the left side of triode 170 increases to an amount as determined by the setting of arm 171 on the potential divider associated with the grid in the right side of the triode 170, the left side of the triode 170 will begin to pass current and the right side of triode 170 will become nonconductive. When the left side of triode 170 becomes conductive a surge of current will pass through the coil of relay TL to energize this relay.

Energization of relay TL reverses its contacts from the normal position shown, thus providing activation of an alarm 175 and a ground connection to selector switch section 78c.

Selector switch section 78c is ganged with switch section 78d in multi-position switch 78, and in its rightmost position as illustrated and in its center position, provides a ground connection for relay RS through contacts of relay TL and line 61 when relay TL is energized. Thus relay RS is energized after the time delay of unit 58, and thus in response to sustained rate of charge beyond the threshold as described above.

Energization of relay RS provides illumination of the delayed alarm 63 as well as an output via lead 66′ for control of other devices. Relay RS and selector switch 78 are included in the Hold/Release Selector 62 which is illustrated in block form in FIG. 2b and also shown on the control panel in FIG. 4. Adjustment of switch section 78d to its rightmost position provides a lock-in circuit for relay RS via its upper contact which is connected to ground through a remote reset switch 64. Adjustment of switch 78 to its center position opens the lock-in circuit for relay RS but maintains the operating circuit under control of relay TL to be operated and released directly with the latter. Adjustment of switch 78 to its leftmost position disconnects relay RS. Thus switch 78 may be changed from its rightmost position momentarily if desired for local reset.

The relay RS is provided in the preferred circuit illustrated to give greater flexibility of output control and to permit heavier duty contacts to be employed on relay RS while leaving relay TL as a lighter duty relay for example. If desired, however, the functions of these relays might be combined in relay TL by adding contacts and conventional circuitry.

Referring again to the time delay unit 58 and its control by the coincidence threshold response unit 52 as shown in FIG. 3, it will be noted that the time delay unit 58 is controlled via two input circuits from contacts of relay VSL as part of the output of unit 52. These two circuits are 56(a) from make contact 152 and 56(b) from break contact 153. It will be appreciated that if desired the functions of these contacts in supplying D.C. for charging the time capacitor 154 and opening the discharge or reset circuit therefor could be transferred to a separate relay which might be added in unit 58 and controlled by a single lead 56 or 56′. The circuits 56(a) and 56(b) in FIG. 3 may be considered a part of control line 56 or 56′ in FIG. 2b.

It will also be appreciated that the time delay unit 58 may be controlled by the circuit 56(b) from contact 153 alone if the circuit 56(a) were shunted around the contact 152 to connect directly with the D.C. power supply which serves unit 58 via lead 69.

Although for convenience the D.C. power supply for time delay unit 58 is drawn from that available in unit 52 below in FIG. 3, the unit 58 may have its own power supply if desired.

Although the above description with reference to the circuit diagram of FIG. 3 and the block diagrams of FIG. 2, has set forth certain preferred aspects of the invention and certain modifications of the invention, other aspects of the invention include cooperation of either of the rate of change circuits with either of the "coincidence" or threshold response units, as well as cooperation of both rate of change circuits with both coincidence or response units for response to rates of change of traffic volume and traffic speed in opposite directions.

Thus while units **52** and **53** have been referred to in part above as change coincidence units, particularly in responding to concurrent conditions of changing speed and volume, it will be appreciated that either unit may serve as a threshold response unit either for the rate of change of speed alone by the omission or disconnection of the rate of change of volume unit, blocks **87** and **54**(*v*) in FIG. 3 for example, or for the rate of change of volume unit alone by the omission or disconnection of the rate of change of speed unit blocks **88** and **54**(*s*) in FIG. 3 for example. As an alternative, for selective operation of unit **52** from either the speed unit or the volume unit or both, switches may be placed in the lines above and below junction **131**, on either side of capacitors **137** and **138** in FIG. 3, to open or close these circuits individually as desired in unit **52**. Similar provision may be made in unit **53** if desired.

Various combinations of units include the speed rate of change unit alone cooperating either with coincidence or response unit **52** alone adjusted for response to decreasing speed alone or with coincidence or response unit **53** alone adjusted for response to increase speed alone, the volume rate of change unit alone cooperating either with coincidence or response unit **52** alone adjusted for response to decreasing volume or with coincidence or response unit **53** alone adjusted for response to increasing volume. Other combinations for response to different concurrent conditions include both the rate of change of speed and the rate of change of volume units cooperating with a coincidence unit such as **52** but with diodes **114** and **114'** reversed from that shown in FIG. 3 and limit adjust **54**(*s*) adjusted for response to increasing speed and diodes **115** and **115'** as shown in FIG. 3 and limit adjust **54**(*v*) adjusted for response to decreasing volume so that the output of unit **52** as modified would be in response to concurrently increasing speed and decreasing volume, or the reverse combination with diodes **114** and **114'** as shown in FIG. 3 and limit adjust **54**(*s*) adjusted to respond to decreasing speed and diodes **115** and **115'** reversed as compared with FIG. 3 and limit adjust **54**(*v*) adjusted to respond to increasing volume so that the output of unit **52** as modified would be in response to currently decreasing speed and increasing volume.

Thus in more general terms the circuits may be readily arranged for response to the rate of change of speed alone exceeding a predetermined amount in a predetermined direction of change, or for response to the rate of change of volume alone exceeding a predetermined amount in a predetermined direction of change, or for response to concurrent rates of speed and volume of predetermined amounts and in predetermined directions of change, which may be the same directions or opposite directions.

As previously mentioned, the limit adjusters **54**(*s*) and **54**(*v*) may be individually adjusted for different values and over a wide range, such as to obtain coincidence response to a 10% decrease in the rate of change of speed and a 15% decrease in the rate of change of volume, with the diodes as shown in FIG. 3, for example, or a 2% increase in the rate of change of speed and a 5% decrease in the rate of change of volume, with diodes **114** and **114'** reversed, for example, or any other desired values.

FIG. 4 illustrates a form of control panel that may be employed in one embodiment of the invention.

Similar electrical components that appear in part on the control panel of FIG. 4 and also in FIG. 2*b* and FIG. 3 are similarly labeled, as for example meters **43** and **44**, range adjusters **45** and **46**, limit indicator **57** and "remote alarm" **63** which may be an alarm itself or an indicator lamp on the panel to show when a remotely located alarm is operated. The time delay adjustment **77** and indicator lamp **175** correspond to similarly labeled components illustrated in FIG. 3. The scale above the time delay adjuster **77** may be in minutes for example.

Certain blocks on the control panel are expanded below the face of the panel for convenience in the drawing to make the legend appearing thereon legible. Thus the legend, "Speed Computer Change in M.P.H./Minute for Full Scale on Meter" refers to the scale of figures associated with the adjusting knob of the speed range adjustor **45**, and the large horizontal arrow identifies the associated speed rate of change meter **43**. Similarly the legend "Volume Computer Change in %/Minute for Full Scale on the Meter" associates the range of values of the volume range adjustor **46** above it with the volume rate of change meter to the left. The ranges of values for the several meters and adjustors serve as examples without limitation thereto.

Neither of the limit adjustors **54**(*s*) or **54**(*v*) comprising the limit adjust **54** appear on the control panel as shown in FIG. 4. It is anticipated that the limit adjustors **54**(*s*) and **54**(*v*) will be varied much less often than the adjustments that appear on the control panel, and thus may be more suitably located elsewhere in or on the apparatus, but it will be understood that such limit adjustors may be located on the control panel of FIG. 4 if desired.

FIG. 5 illustrates another form of exit ramp from an expressway, parkway or the like, the exit ramp extending from a deceleration lane on the expressway. The arrow **13** indicates the direction of vehicle travel, as the similar arrow in FIG. 1, and the lines **11** and **12** in FIG. 5 represent the limits of one half of the expressway as in FIG. 1 above. The exit ramp **26'** terminates at the intersection of a roadway indicated by lines **30** and **30'**. The bridge **29** indicates that the roadway **30–30'** is illustrated as passing under the expressway **11–12** for example.

The diagrammatic showing in FIG. 5 and particularly the length of the roadway **11–12** and of the exit ramp **26'** in FIG. 5 are condensed or foreshortened for convenience of illustration.

A vehicle speed and passage sensing unit **17**, similar to the corresponding labeled detector in FIG. 1, is illustrated over the exit ramp in FIG. 5. The unit **17** would be suspended over the roadway by means of a pole and projecting arm or by means of a span wire, or other means.

Sensing unit **17** is preferably placed over the exit ramp intermediate the ends of the ramp and at least several car lengths in advance of the signal **50** so as to sense vehicles in the normally relatively free moving traffic zone along the ramp rather than the first few cars stopping or slowing down at the entrance to the lower road **30–30'** for example.

Thus the sensing unit **17** may be located generally near the middle of the length of the ramp as shown for example, so as to sense congestion or blocking soon enough to warn approaching traffic or to clear the accumulated traffic through the lower signal or road intersection but not to be unduly affected by ordinary changes in speed or in volume occurring directly adjacent to the intersection.

The box **23'** in block form, represents one or another of the forms of apparatus mentioned above for responding to decreasing speed or to concurrently decreasing speed and volume for example, as more fully discussed below.

This line **24'** represents an output line through which a sign **25'** would be illuminated or otherwise controlled so as to warn approaching vehicles on the deceleration lane of the condition of the exit ramp. The sign **25'** is illustrated by way of example only for other signs as desired may be used in its stead or cooperatively with the sign **25'**.

The line **49** represents an additional output line extending to a block **40** which block represents a controller which controls the traffic signal **50** through line **51**. The traffic signal is preferably of the usual type having red, yellow and green signal lights for the several directions, as indicated by the small arrows for example. The controller in block **50** may include one of the well known types of traffic signal controllers for operating the signal lights through a time cycle to accord right of way to the intersecting roads in sequence, and in addition will preferably include a supplemental preemptive controller for acting through or superseding the normal traffic signal controller to preempt or otherwise obtain the right of way for the exit ramp to permit the accumulated traffic on the exit ramp to be reduced or cleared into the intersection.

Several forms of preemptive control of traffic signals in connection with or superseding a traffic signal controller are illustrated in U.S. Patent 2,203,871 issued June 11, 1940, to W. R. Koch and in U.S. Patent 2,234,606 issued March 11, 1941, to F. H. Richterkessing.

The preemptive controller may be operated by a threshold response unit such as **52** from output line **56** for example either in response to substantially decreasing speed alone or in response to concurrently decreasing speed and volume as discussed above, or as otherwise discussed below.

The unit **23'** in FIG. **5** may be of the same type as unit **23** above in FIG. **1** for example, or may employ only part of the apparatus shown in the latter. It will be understood that either of these units **23** or **23'** may employ both the upper and lower parts of FIG. 2*b* for concurrent negative change operation response for speed and volume and for concurrent positive change release response for speed and volume, or may employ only the upper part of FIG. 2*b* for the negative change response without the positive change response, as well as other variations discussed above.

Although preferably the unit **23** particularly would employ response to concurrently decreasing speed and volume of traffic for control of signs or signals, either of the units **23** and **23'** and particularly unit **23'** in some circumstances might use decreasing speed alone as by only speed circuit **88** and limit adjust **54**(*s*) feeding into threshold response amplifier unit **52**, or might use sustained low speed below some value considered critical such as by the successive critical speed response unit of the above mentioned copending application S.N. 777,711 on "Traffic Speed Monitor" for example, for control of the signs or signal, or for operation of the preemptive controller for control of the signal to accord right of way to traffic entering the road **30–30'** from the ramp.

The exit ramp may have other well known forms where traffic from the ramp merges with traffic on the other road and is normally free flowing throughout without traffic signal or other stop and go control. It will be understood that the exit ramp may also sweep in an arc from the expressway to the right and backward from the far side of the bridge **29** in the familiar "clover leaf" pattern instead of in the form illustrated in FIG. 5.

It will be understood that the advance warning sign **25'** alone may be employed to be operated in response to sustained low or substantially decreasing speed alone or to a combination of decreasing speed and volume, or the preemptive controller may be employed alone to be so operated, or both sign and preemptive controller may be employed as in the preferred form illustrated.

The wording of the signs in the several drawings is primary for illustrative example and other wording may be found suitable in some cases until adoption of some accepted standards for such service.

It will be noted that the term negative rate of change is used to describe a rate of change in the direction of decrease. Similarly a positive rate of change is in the direction of increase.

Although a number of aspects of the invention and modifications of the form thereof have been described above, it will be understood by those skilled in the art that various other modifications might be made or rearrangements or substitution of parts and the like without departing from the spirit of the invention within the scope of the claims.

I claim:

1. A traffic control system for a roadway including
means for sensing a characteristic of traffic flow along said roadway, said sensing means providing an electrical signal output having a running average value representing a running average of said traffic flow characteristic as averaged over a series of vehicles in said traffic flow,
means for providing from said output a further electrical signal output having a value representing the rate of change of said average value as representative of the rate of change of said sensed traffic flow characteristic,
indicating means, and
threshold response means coupled to said indicating means and to said further output for controlling said indicating means in response to said further output beyond a predetermined value representing a rate of change in said traffic flow characteristic beyond a predetermined minimum.

2. A traffic control system as in claim **1** and in which said indicating means includes
means for selectively controlling traffic for permitting said traffic to proceed on said roadway in absence of said output and for diverting traffic from said roadway in response to said output respectively.

3. A traffic control system as in claim **1** and including means for holding said indicating means operated after and despite cessation of said output and until released, and resetting means for so releasing said holding means.

4. A traffic control system as in claim **1** and including timing means for controlling such operation of said indicating means to permit such operation only after a predetermined period of continuous such output.

5. A traffic control system for an exit ramp from an expressway or the like to another road, including
means for sensing a characteristic of traffic flow along said exit ramp, said sensing means providing an electrical signal output having a running average value representing a running average of said traffic flow characteristic as averaged over a series of vehicles in said traffic flow,
means for providing from said output a further electrical signal output having a value representing the rate of change of said average value as representative of the rate of change of said sensed traffic flow characteristic,
traffic control means near one end of said ramp,
and means coupled to said traffic control means and to said further output for controlling said traffic control means in response to said further output beyond a predetermined value representing a rate of change in said traffic flow characteristic beyond a predetermined minimum amount in a predetermined direction of change.

6. A traffic control system as in claim **5** and in which said traffic flow characteristic sensing means includes
means sensing the speeds of vehicles in said traffic flow to provide said electrical signal output as representative of the speed of traffic as said traffic flow characteristic,
and in which said traffic control means includes indicating means for traffic on said expressway approaching said ramp,
and said means for controlling said traffic control means includes means for operating said indicating means in response to said further output beyond a predetermined value in a predetermined direction of change representing decreasing speed.

7. Electrical apparatus for use with a system having means for measuring a characteristic of flow of vehicular traffic and providing an electrical signal having a value representative of a running average of said traffic flow characteristic, said apparatus including in combination,
differentiating means adapted to be connected to said traffic measuring means for receiving said electrical value signal, said differentiating means producing a direct current voltage output representative of the rate of change of said electrical value, said direct current voltage having a range of values corresponding to a range of rates of change between a maximum rate of decrease through zero to a maximum rate of increase,
a potentiometer connected across a direct current voltage supply and having a movable arm for setting a desired threshold voltage corresponding to a desired rate of change of predetermined amount and direction, and
a circuit including two similarly poled rectifiers and an impedance in series connecting said direct current voltage output and said movable arm;
an amplifier having an input,
an alternating current supply,
a high impedance connecting said alternating current supply with said input, and
a circuit including a capacitor connecting said input to a point between said rectifiers in the first mentioned circuit;
whereby said alternating current voltage will be shunted from said input when said direct current voltage and said threshold voltage have one relation in magnitudes to maintain one of two alternate conditions of conductivity and non-conductivity for said rectifiers, and whereby said alternating current voltage will be available at said input to be amplified by said amplifier to provide an output in response to a rate of change of at least said predetermined amount and direction when said direct current voltage has a generally opposite relation to said threshold voltage in magnitude to maintain the other of said two alternate conditions for said rectifiers.

8. In combination,
means for sensing vehicles passing a desired point in a traffic lane, said means producing an electrical signal having a running average value representing the running average of traffic speed of said vehicles in said lane,
differentiating means for producing a further electrical signal having a value representing the rate of change of said average value, and
means for producing an output in response to said further value reaching a predetermined amount in a predetermined direction of change.

9. In combination,
means for sensing vehicles passing a desired point in a traffic lane, said means producing an electrical signal having a running average value representing the running average of traffic volume in said lane,
differentiating means for producing a further electrical signal having a value representing the rate of change of said average value, and
means for producing an output in response to said further value reaching a predetermined amount in a predetermined direction of change.

10. A traffic control system including
means for sensing traffic flow, said sensing means providing an electrical signal value varying in proportion to an average value of said traffic flow,
differentiating circuit means connected for receiving said electrical signal for providing an output signal representing the rate of change of said average value of traffic flow,
biasing means for providing a reference level for said output signal, and
means for providing a control signal in response to said output signal exceeding said reference level of said biasing means.

11. A traffic control system including
means for sensing traffic flow, said sensing means continuously providing an electrical signal output representing an average value of said traffic flow over a time period, said electrical signal varying slowly in amplitude with variations in said traffic flow with respect to time,
a junction,
a condenser connected between said signal output and said junction,
a resistor connected between said junction and a reference point, said resistor and condenser being coupled to provide a signal between said junction and said reference point representing the rate of change of said average value,
means for connection to said junction and said reference point for providing a control signal in response to a predetermined rate of change, and
means including
time delay means for controlling traffic in response to said control signal when sustained for said time delay.

12. In combination,
means for sensing traffic flow, said sensing means providing an electrical signal varying in amplitude with the average value of said traffic flow over a time period,
means for differentiating said electrical signal to provide an output signal representing the rate of change of said traffic flow,
means connected to said output for indicating the rate of change,
threshold bias means,
comparison means including a diode,
means connecting said bias means for reverse biasing the diode,
means connecting said output signal for forward biasing said diode so that rates of change output signal values above said bias result in conduction of said diode, and
traffic control means coupled to said diode to be operated responsive to said diode conduction.

No references cited.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,275,984

September 27, 1966

John L. Barker

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 22, for "passing" read -- passage --; column 6, line 75, after "from" insert -- time --; column 7, line 27, after "change", second occurrence, insert -- unit --; line 65, for "instances as a suppliement" read -- instances or as a supplement --; line 71, after "line" insert -- block --; column 10, line 44, for "15′" read -- 115′ --; column 15, line 69, for "primary" read -- primarily --.

Signed and sealed this 26th day of November 1968.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents