TRAFFIC SUPERVISORY SYSTEM

Filed May 13, 1957 6 Sheets-Sheet 1

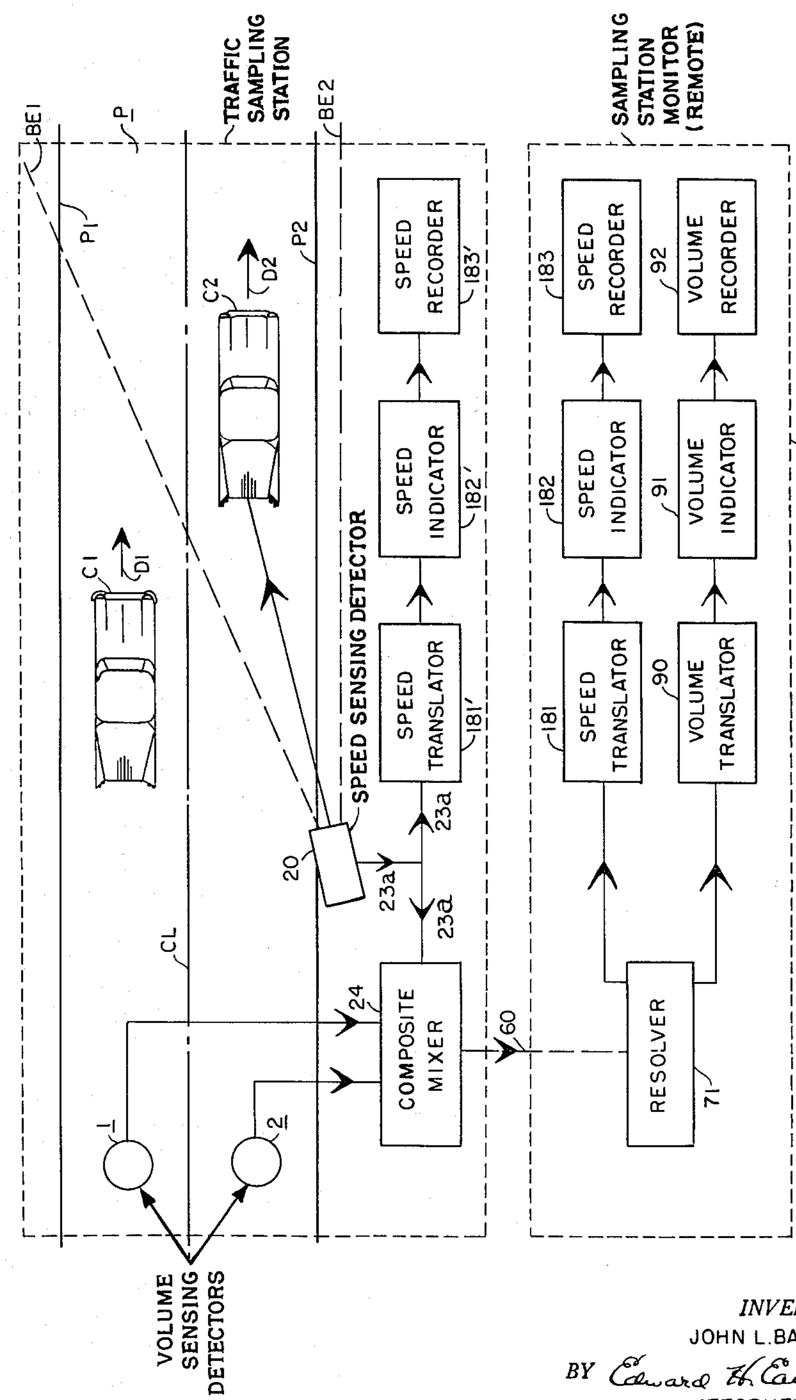

Fig. 1

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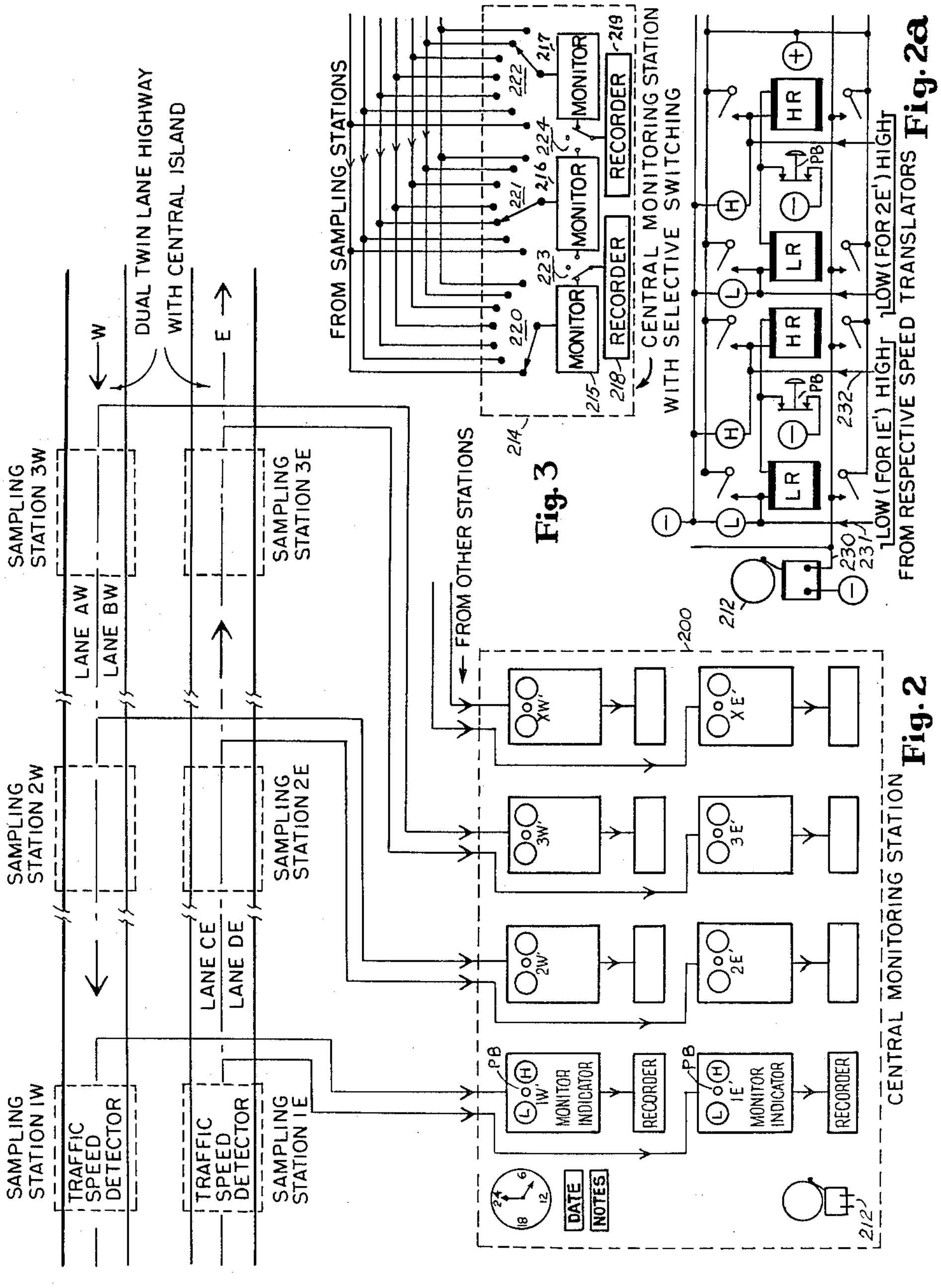

Fig. 3

Fig. 2a

Fig. 2

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TRAFFIC SUPERVISORY SYSTEM

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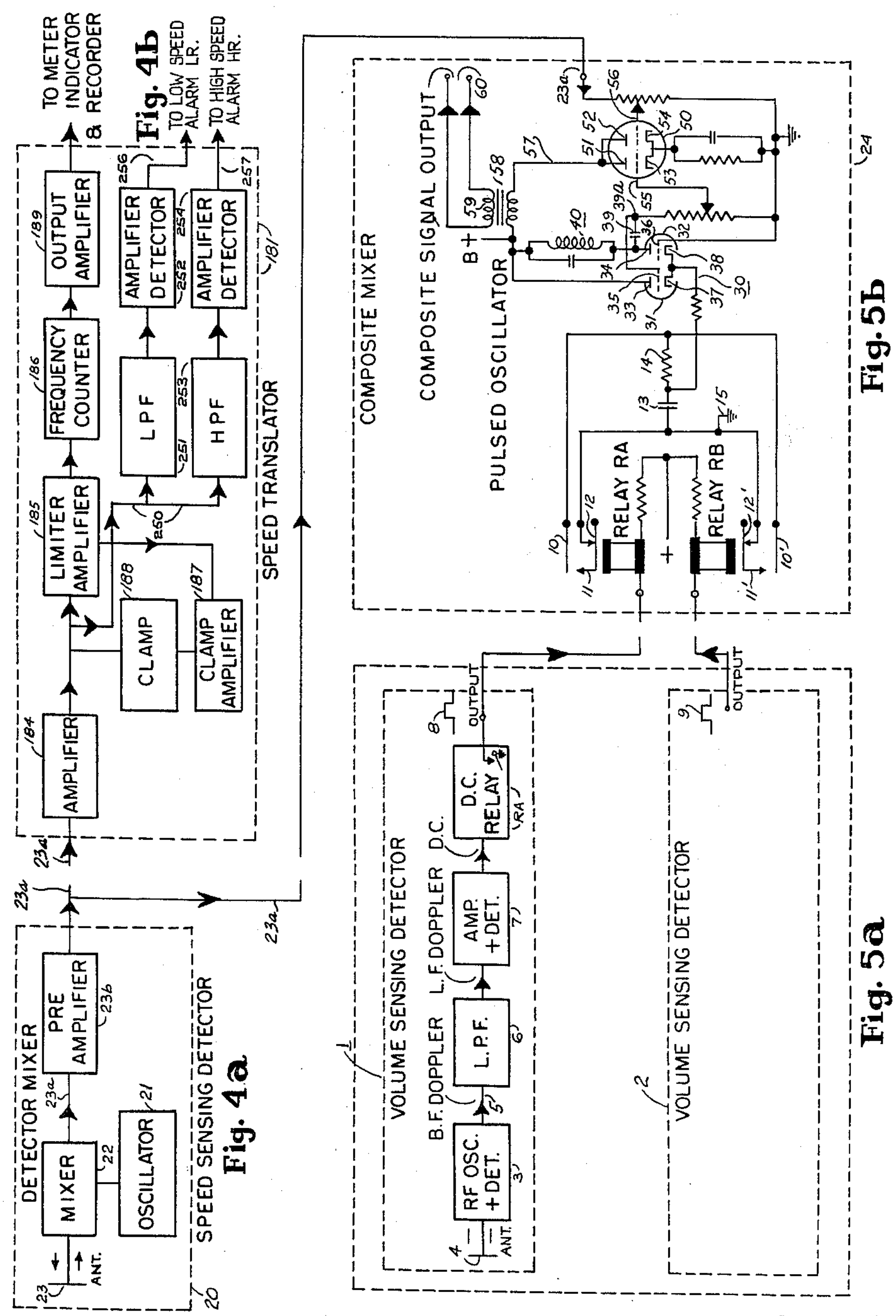

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TRAFFIC SUPERVISORY SYSTEM

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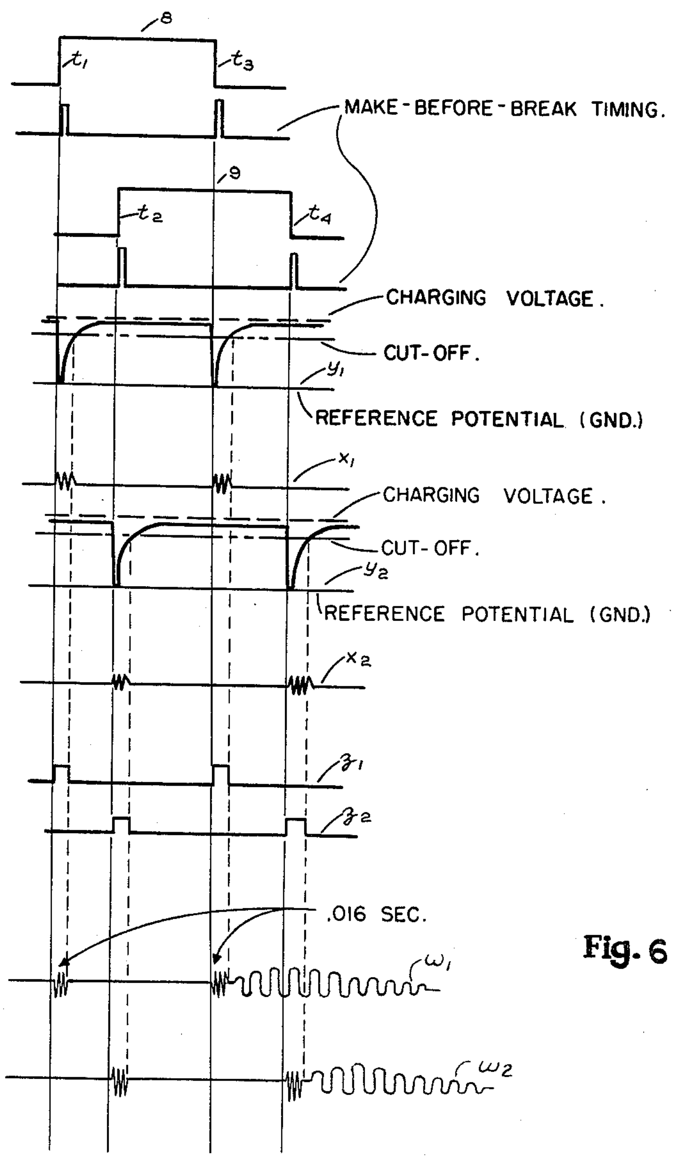

Fig. 6

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TRAFFIC SUPERVISORY SYSTEM

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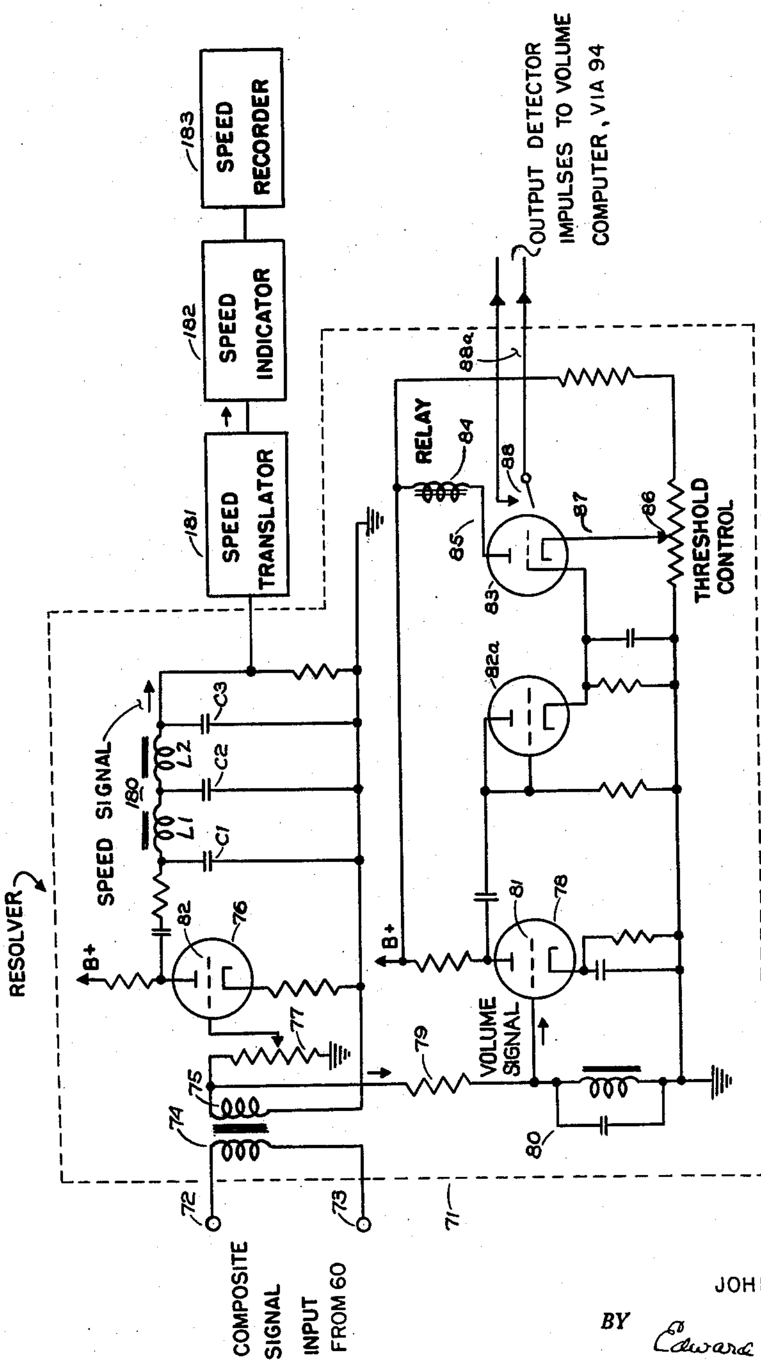

Fig. 7

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TRAFFIC SUPERVISORY SYSTEM

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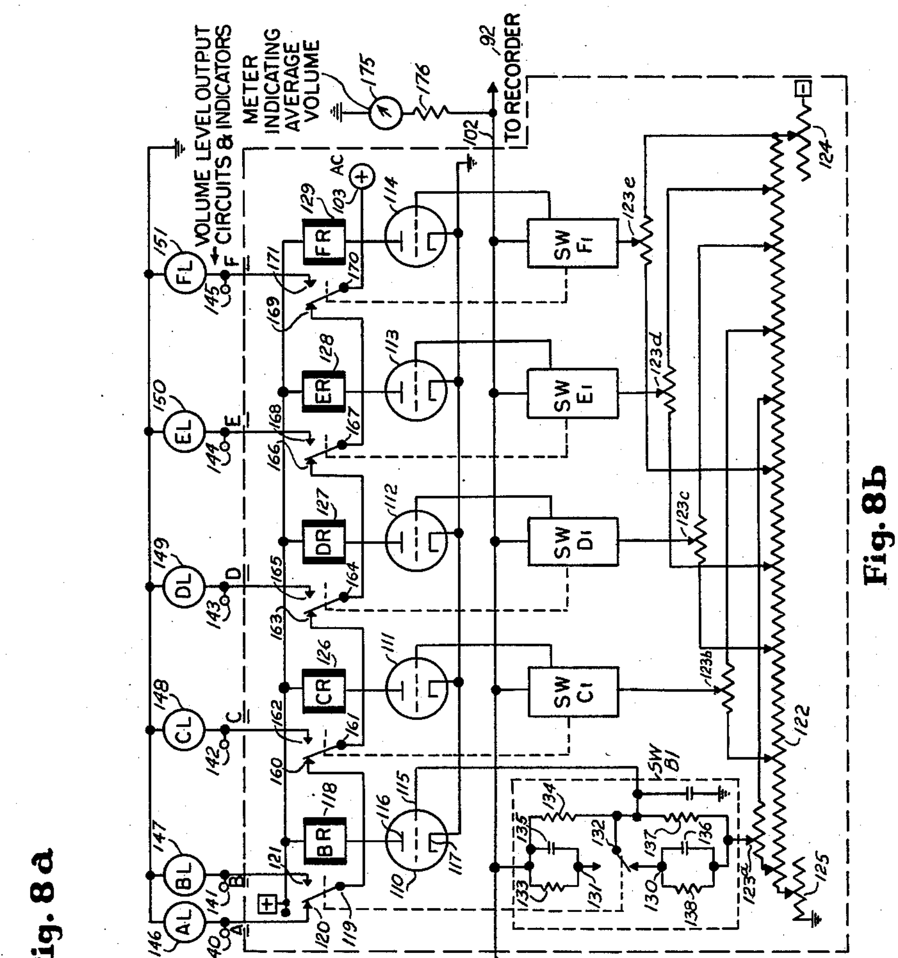

Fig. 8b

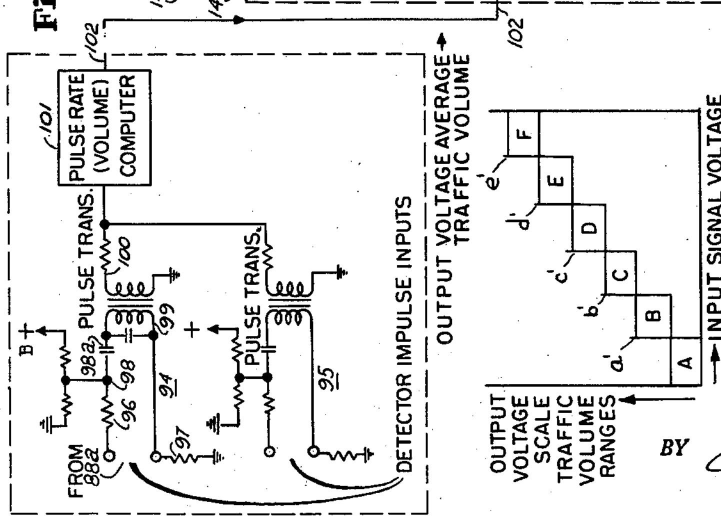

Fig. 8a

Fig. 9

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United States Patent Office 3,195,126
Patented July 13, 1965

3,195,126
TRAFFIC SUPERVISORY SYSTEM

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Filed May 13, 1957, Ser. No. 658,704
8 Claims. (Cl. 343—7)

This invention relates to a system for remote or centralized recording and/or indicating of the speed and/or volume of moving traffic such as vehicles on a traffic pathway, and in particular to means for obtaining and recording or indicating for specific and/or average intervals of time the traffic volume and speed of a single or group of highway facilities at one or more sampling points or spaced intervals along such facilities. The term highway facilities is intended to include without limitation highways, parkways, throughways, turnpikes and other heavily travelled traffic facilities for example.

Highway facilities designed for particular vehicular speeds and traffic volumes may under certain conditions become inadequate so that means have to eventually be provided for alleviating the inadequacy, either by increased highway personnel, or by modifying and/or adding new highway facilities. To provide for the advance planning of such proposed facilities, means are required to maintain proper and continuous records of the performance of the facility. Such records may be in the form of visual observations which, of necessity, require substantially large personnel to adequately cover the facilities. This form of record keeping would be costly and subject to error because of the human element involved.

Further, it is necessary at times to have an immediate spot check of any given facility at various stations to determine the traffic conditions thereat and to take any necessary steps to alleviate any irregular conditions which may exist at the particular station. This again requires increased personnel to maintain strict vigilance in assuring that normal highway conditions will not be disturbed.

According to a preferred aspect of the invention as contemplated herein, there is provided a plurality of spaced sampling stations along a given highway facility, each sampling station being provided with means for sampling traffic speed and traffic volume, and for developing signal information indicative of said volume and speed, such information then being relayed to a remote or centralized monitoring station for recording or indication there.

According to a further aspect of the invention such speed and volume indicative signal information is derived at one or more such sampling stations and is then combined and transmitted via common transmission facilities to a central monitoring station where the said combined signal information is received and separated according to the aforementioned volume and speed indicative signal information. The speed and volume signals are then processed by speed and volume indicator units and preferably recorded graphically for permanent viewing.

According to other aspects of the invention centralized speed information from spaced sampling points along a highway facility may have significant application without the volume information. Another feature of the invention resides in providing alarm facilities, at the central monitoring station, adapted to provide audible and/or visual signal means responsive to speeds or average traffic volumes which exceed or fall below set pre-determined levels.

It is, therefore, an object of this invention to provide

an improved type traffic surveillance or supervisory or monitoring system for highway facilities.

It is another object of this invention to provide apparatus at spaced sampling stations along a highway facility for detecting the presence and speed of vehicles moving along said highway facility.

A still further object of this invention is to provide apparatus at one or more sampling stations along a highway facility for combining received traffic information indicative of speed and volume at the sampling station and transmitting such information along a pre-determined transmission path to a central monitoring station where the said information is monitored.

And a still further object of this invention is to provide, in a traffic surveillance system, a plurality of traffic sampling stations having traffic speed and/or volume detecting means and a central monitoring station therefor, said monitoring station having a lesser number of traffic volume and/or speed indicators and/or recorders selectively connectible to various individual such speed and/or volume of moving vehicles past the sampling stations selected for surveillance, and to graphically record such information indicative of speed and volume for pre-determined periods of time.

Another object of this invention is to provide, in a traffic surveillance system, alarm circuitry operably responsive to excessive or low speeds, and/or high or low volume.

Further objects, features and advantages of the present invention will become apparent by references to the following description taken in conjunction with the following drawings wherein:

FIG. 1 shows a typical traffic sampling remote monitor station and apparatus for receiving traffic information indicative of the traffic speed and traffic volume.

FIG. 2 shows a plurality of spaced sampling stations disposed along a highway facility and a central monitoring station for receiving individually traffic information from the sampling stations with associated alarm indicators.

FIG. 2*a* shows alarm circuitry for use with FIG. 2.

FIG. 3 shows a central monitoring station with selective switching apparatus for selectively associating individual monitor and recording equipment with individual sampling stations.

FIG. 4*a* shows a speed sensing detector and FIG. 4*b* a speed translator, both in block form, for obtaining speed information of passing vehicles.

FIG. 5*a* shows in block form two units of one form of volume sensing detector for obtaining signal information indicative of the number of passing vehicles in any given interval of time.

FIG. 5*b* shows circuitry comprising a composite mixer for producing a composite signal from signal information received from both volume and speed sensing detectors.

FIG. 6 illustrates graphically the wave forms of the signals produced by the volume detector apparatus and the speed detector apparatus and the composite mixer.

FIG. 7 shows circuitry for resolving, i.e. separating the speed and volume signals from the received composite transmitted signal.

FIG. 8*a* shows schematically a pair of detector impulse input circuits and a volume computer providing an output voltage proportional to average volume as determined by the rate of such impulses, as received from the volume output of the resolver of FIG. 7.

FIG. 8*b* shows according to one form of the invention, circuitry for classifying volume information by dividing the output voltage scale into adjustable segments or output levels in accordance with traffic volume, said levels being positively and rapidly switched in one level at a time according to the traffic volume.

FIG. 9 shows graphically the volume graduated levels or segments over the over-all scale with no overlapping of segments or levels.

Referring now to FIG. 1, there is shown in block form a traffic surveillance or monitoring system taken at a generally typical location along a highway facility where the traffic prevailing is sampled as to speed and volume, and the information indicative thereof transmitted to a remote monitoring station.

The highway facility is shown by upper and lower horizontal lines P1 and P2 representing the two edges of a roadway P for vehicular traffic. For the purpose of showing one form of applying the invention to a roadway carrying one-way two lane vehicular traffic, the lane line CL of the roadway is shown by the broken line along the middle of the roadway and a pair of cars C1 and C2 are shown traversing the highway in the same general direction from the left side of the figure and proceeding to the right side as shown by the arrows D1 and D2 in the dual lanes on either side of the highway lane line CL.

This illustrates one half of a typical four lane divided highway, which may include throughway or parkway, for example.

A pair of volume sensing detectors 1 and 2 are each generally disposed over and above the respective dual lanes a distance of the order of 16 to 18 feet for example to secure the best traffic coverage. The volume sensing detectors 1 and 2 are each positioned, and adapted to transmit microwave energy and receive such energy reflected from passing vehicles, such received wave energy being detected and converted to appropriate signals adapted for convenient transmission over normal communication channels.

The volume sensing detectors 1 and 2, as contemplated in the present invention, and shown in block form in FIG. 5*a*, each substantially comprises a combined radio frequency oscillator and detector 3 for transmitting and receiving microwave energy via a microwave antenna 4, and thereby producing a Doppler beat frequency 5 in the output of the oscillator-detector 3 in response to the passage of motor vehicles along the highway facility. As a vehicle approaches the volume sensing detector, the angle between the vehicle's direction of travel and any incident radio wave from the transmitter is relatively small, giving a Doppler beat of nearly true value corresponding to the speed of the vehicle, i.e., a relatively high frequency. A low pass filter 6 is provided, which reduces the zone of response operation. Since a vehicle passing under the unit at any speed is subject to the reduction of frequency of the Doppler beat note, due to the cosine effect or the angle between the direction of movement of the vehicle and the direction of transmission of the radio waves, to essentially zero, the length of time that the Doppler beat note is reduced to a value which will be passed by the amplifier 7 is roughly inversely proportional to the speed of the vehicle.

The result is that the volume sensing detectors 1 and 2 will produce a relatively long impulse for a slow-moving vehicle and a relatively short impulse for a fast-moving vehicle, the pulse starting at the time when the vehicle enters into the corresponding effective zone of the transmission beam and ending when the vehicle leaves such effective zone.

FIG. 6 illustrates the pulse wave forms 8 and 9 for a pair of vehicles moving in the same general direction, starting at times *t1* and *t2* when the respective vehicles come into the zones of the beams and ending at times *t3* and *t4* when the respective vehicles move out of the zones of the beams. It can be appreciated that wave forms 8 and 9 commence at different times indicating that the vehicles come into the zones at different times. Any error produced by the vehicles coming into the beam zone coincidentally, one distinguishable wave form being produced as a result, would be rather small and insignificant in view of the remote possibility that two vehicles would be completely aligned at the beam fronts at the same time.

The resulting wave forms 8 and 9, produced by the volume sensing detectors, are then transmitted to a pair of detector relays RA and RB, shown in FIG. 5*b*. The relays RA and RB as shown in FIG. 5*b* are located preferably with and forming a part of the composite mixer 24, the said mixer to be subsequently described. The location as to the relays may be altered, e.g. the relays may be located within the volume sensing detectors to form a part thereof as illustrated by the block "D.C. relay" in FIG. 5*a*.

The relays RA and RB, are of the make-before break type and operable on D.C. pulses produced by the volume sensing detectors in the wave forms 8 and 9 shown in FIG. 6. Since the impulses from a pair of volume sensing detectors might overlap by an appreciable amount, as above stated, when cars are in the zones of both units at the same time, and thus give a single output impulse if the circuits are directly connected in parallel, means are provided for elimination of this source of error. This is accomplished through the make-before break contacts on relays RA and RB. Actuation of relay RA provides a short interval of closure of contact 10 to 12 during the movement of such contact, and discharges a charged capacitor 13 through 14 to ground 15. The operation of the make-before-break contact gives two impulses for each single operation of either RA or RB; namely, an impulse when the relay is energized and another impulse when the relay is deenergized. These impulses cause the contacts 10 and 12 of relays RA and RB to connect the capacitor 13 to ground.

FIG. 5*b* further shows one preferred form of blocking oscillator 30, comprising dual triode stages 31 and 32 each having respectively anodes 33, 34, grids 35, 36 and cathodes 37, 38. The triode stages are each respectively coupled via capacitor 39 from anode 34 to grid 35 and via the cathodes 37, 38. The frequency of oscillation of the oscillator is determined by the tuned circuit 40.

In operation, the oscillator is blocked (no conduction in the anode 34) by virtue of the high positive bias placed on the cathode 38 produced by the charged capacitor 13. Upon the discharge of capacitor 13 to a source of reference potential, namely ground, through resistance 14, the oscillator 30 becomes operative, thereby producing in the output 39*a*, a series of oscillations whose frequency is dependent upon the tuned circuit 40, and preferably of the order of 2000 cycles. As aforementioned, the discharge of capacitor 13 in accordance with impulses from the volume sensing detectors, which cause relay RA and RB to function respectively, will render the blocked oscillator operative to produce a series of oscillations whose duration is dependent upon the time constant of the capacitor 13 and the plate resistance of the oscillator 30, and preferably of the order of 16 milliseconds for example.

The 2000 cycle signal is then transmitted to a mixing stage 50. The mixer 50, of composite mixer 24, comprises a pair of triodes in a single envelope wherein the anodes 51, 52 and cathodes 53, 54 are connected together and the control grids 55, 56 are independent of each other. The signals to be mixed, or added, are transmitted separately to the independent control grids 55, 56 and added in the plate or anode circuit 57 of the mixer.

As previously described, the volume detector impulses 8 and 9 each produces two bursts of 2000 cycle oscillations, one at the leading edges *t1* and *t2*, and another at the trailing edges *t3* and *t4* as illustrated in wave forms *x1* and *x2* respectively in FIG. 6. The burst for each impulse lasts for a period dependent upon the time constant of the capacitor 13 recharging circuit. Representative curves *y1* and *y2* of FIG. 6 shows the charge and discharge curves for capacitor 13 and the point of cut-off for the oscillator stage. Curves $x1$ and $x2$ each depicts the burst and its duration for the period of time where the capacitor voltage is less than cut-off, with the tubes oscillating, as shown by the capacitor discharge-charge curves $y1$ and $y2$.

Referring to FIGS. 1 and 4a–4a there is shown a speed sensing detector 20, for measuring the speed of objects moving along a substantially predetermined path, and similar to the speed meter described in my U.S. Letters Patent No. 2,629,865 issued to Eastern Industries, Inc., assignee of John L. Barker, on February 24, 1953. The speed sensing detector comprises essentially a combination transmitter-receiver unit having an oscillator 21 and mixer 22 and an antenna 23 for beaming microwave radio frequencies at advancing or receding vehicles in the operating zone and receiving the same frequency back plus or minus a Doppler frequency shift. The Doppler frequency signal 23a is then amplified by pre-amplifier 23b and subsequently transmitted via a composite mixer 24, to a remote monitoring station, where it is ultimately processed into a direct speed reading.

The said Doppler signal may also be processed directly at the point where the Doppler frequency was developed. In the case where the Doppler speed signal 23a is transmitted to the composite mixer 24, the signal 23a is first fed to the control grid 56 of mixer 50 and ultimately mixed in the anode circuit 57 with the aforementioned representative 2000 cycle signal produced from the volume detector sensing signals. The Doppler speed signal is an audible signal, i.e. in the range from 0 to 730 cycles for example, which corresponds approximately to a vehicle travelling at the speed of from 0 to 100 miles per hour. The variable audible signal 23a, having a variable frequency from approximately 0 to 730 cycles, is then combined with the 2000 cycle signal as above mentioned in the mixer anode circuit 57, which circuit further includes a transformer 58. The transformer output 59, when both speed and volume sensing detectors are operated in response to the presence of vehicular traffic, contains both the volume representative 2000 cycle signal and the speed representative 0–730 cycle signal, the respective signals both forming a single composite signal 60, which is subsequently transmitted via some available transmission means. The transmission means can take on any of the normal available forms such as telephone lines and/or radio transmission links.

The composite signal 60, containing both traffic volume information and traffic speed information is subsequently transmitted via appropriate transmission facilities to a remote sampling station monitor 70. FIG. 1 shows in elemental block form the essential equipment for handling both volume and speed vehicular traffic information received from some representative traffic sampling station. The resolver 71 is essentially a frequency separation device which receives the transmitted composite signal 60 comprised of both volume and speed frequency information and separates the said volume and speed frequency information into their separate frequencies, e.g. 2000 cycles and 0–730 cycles respectively.

With reference to the composite signal 60, one form of such signal is illustrated in the wave forms W1 and W2 of FIG. 6. Either W1 or W2 will represent a single vehicle, and W1 and W2 as shown may represent closely spaced vehicles with partially overlapping speed signals, which while shown separately for clearness, would actually be consolidated by simple addition of the voltage waves as well known into a single composite wave form.

The short volume signal bursts in W1 and W2 correspond with those of X1 and X2, and the long low frequency wave trains at the right in W1 and W2 illustrate the Doppler speed frequency signal tapering off in amplitude as the vehicle recedes in the beam. While these volume and speed signals are shown separated in W1 and W2, it will be appreciated that their time relation will depend on the spacing of the volume sensing and speed

sensing detectors. In practical operation the volume signals are separable from the speed signals by the resolver even when overlapping.

The speed signals will actually include a lower frequency initial portion as the vehicle enters the near edge BE1 of the beam due to the cosine effect and this aids in distinguishing partially overlapping speed signals since this introduces a significant dip in or during the consolidated speed signal from partly overlapping signals W1 and W2 for example.

The edges BE1-BE2 of the radio beam may represent half-power points indicating that the major portion of the energy is within these lines, but some energy extends outside sufficient to produce in most cases a readable low frequency initial part of the speed signal.

The beam BE1-BE2 may be angled more or less to the roadway than shown in FIG. 1 to meet individual conditions.

More specifically, as shown in FIG. 7, the resolver comprises a pair of input terminals 72 and 73 connected to an input transformer 74 whose secondary 75 feeds the input stage of an amplifier 76 via a potentiometer 77. A second amplifier 78 has also its input stage fed by the transformer secondary via a coupling resistor 79. Thus the composite signal 60, having both volume and speed representative frequencies, is fed via transformer 74 to both input stages of amplifiers 76 and 78 respectively. The input filter 80 to amplifier 78 comprises a tuned parallel LC circuit, tuned to a resonant frequency of 2000 cycles, so that only that portion of the composite signal 60 having a frequency of approximately 2000 cycles will be extracted therefrom and transmitted to the amplifier 78 via grid 81 and amplified. The composite signal 60 fed to amplifier 76 via grid 82 is amplified and transmitted through a pie type low-pass filter network 180 whose pass-band extends from approximately zero to 1000 cycles. Therefore, essentially all frequencies above 1000 cycles are cut-off, assuring that no volume sensing-frequencies of approximately 2000 cycles are passed or transmitted here.

The 2000 cycle volume signal, after amplification by amplifier 78, is then transmitted to a detector 82a to provide a D.C. operating voltage for relay stage 83. The detected output of the 2000 cycle burst signal, indicative of the presence of vehicles, is shown in pulse form in FIG. 6 curves $z1$ and $z2$. The D.C. voltage or pulse amplitude necessary to cause relay stage 83 to conduct sufficiently, to permit the operation of relay 84 in anode circuit 85, is dependent upon the bias placed on the stage 83 via threshold control variable resistor 86 as applied to the cathode 87 of stage 83. The operation of relay 84, in accordance with the presence of 2000 cycle volume sensing signals, closes contacts 88 and provides the repeated detector impulse at the said contacts and at output 88a, for operation of the volume measuring equipment, which equipment comprises separately the volume translator 90, volume indicator 91 and volume recorder 92.

Referring to FIG. 8a there is shown a pair of input circuits 94 and 95 which are each adapted to function with the output relay circuit 88a of FIG. 7. The operation of relay 84 closes contacts 88 to complete an external circuit of the type illustrated in FIG. 8a. For purposes of illustration there is shown in FIG. 7 only a single resolver having only a single detector output, the said output feeding only one of the input circuits of FIG. 8a. However, where there are a number of sampling stations provided for the purpose of acquiring traffic data over a considerable expanse of highway facilities, if desired to provide an average volume from two sampling stations for example, a pair of resolvers and outputs therefrom may feed the respective input circuits 94 and 95. However, if individual volume averaging or indicating is desired for each sampling station, its resolver output will be the only one connected to the input of the volume translator 90 at FIG. 8*a* and only one input circuit will be used.

With respect to input circuit 94 for example, in absence of a vehicle volume pulse, i.e. when contacts 88 are open, capacitor 98*a* will be charged from the potential divider between B+ and ground, via the transformer primary 99 and resistor 97 to ground. When contacts 88 close upon a vehicle volume pulse, the capacitor 98*a* is discharged quickly via resistor 96 through the primary 99, producing a pulse through the transformer and thus from the transformer output 100 to the pulse rate computer 101.

The pulse rate computer 101 is essentially a device for receiving pulses indicative of traffic volume, i.e. pulses from individual vehicles, and capable of converting such indicative pulses to a D.C. signal whose amplitude varies in accordance with the frequency or number of such pulses per unit of time. The D.C. signal so produced is one capable of being metered by conventional voltmeters, the meter being so calibrated as to give the volume of traffic, either as a direct quantity over a given interval of time or as some percentage of a given traffic volume or rate of flow. A preferred type of pulse or cycle computer measures volume of traffic in vehicles per hour, and although not limited thereto, is disclosed in the Manual for "Electro-Matic" Electronic Cycle Computer, Model MC-11, copyright 1955 by Eastern Industries, Incorporated, assignee of the present application. This computer is also the subject of a copending patent application by me. This type of instrument is adapted to receive a pair of impulses, as shown in FIG. 6, curves *z1* and *z2*, each pair giving an indication of only one vehicle. In other words, two pulses or actuations are equal to one vehicle. However, it can be appreciated that two impulses are not necessary where it would be sufficient to have only one, as for example by using the leading edge only of the pulses 8 and 9.

Whatever system of such pulses is used, it is the function of the computer to convert the incoming pulses to an output voltage which varies as a direct function of the traffic volume. In other words the voltage produced by the computer varies linearly with respect to the traffic volume, and corresponds to the traffic level as averaged over the selected time period, which latter may be adjustable. The computer output voltage 102 is applied to a classification system to operate selectively one at a time of the six output circuits 140–145 shown in FIG. 8*b*, each of the output circuits being responsive to a given range of computer output voltages indicative of the corresponding range of traffic volume.

This preferred arrangement of the output circuits is especially adaptable for automatic surveillance of facilities where it is desirable to know the volume level at the highway facility especially if it had reached a critical high level or critical low levels, since alarm circuits may be operated from the low or high output circuits or both, if desired. In addition these output circuits could be connected to elapsed time indicators to indicate the total number of operation hours of the facility in any six preselected volume ranges.

It is desirable to have each of the volume ranges completely independent of each other, e.g. with no voltage overlap. In other words, in transferring the volume range from one level to another, it is desirable to have the transfer occur at as close as possible to the same value for increasing and decreasing traffic volumes. In order to accomplish this fast switching action, and to avoid any lag or back lash in going from one indicated level to the next indicated level, a snap action with essentially no differential is provided in the aforementioned output circuit switching through the combined use of tubes, relays, capacitors and resistors as will be now described.

Referring again to FIG. 8*b*, there is shown a series of output stages A, B, C, D, E, and F, each stage representing a given volume range of traffic. Stage A, representing the lowest and initial volume range has no control element and is connected directly to the A.C. power source 103 via the back contacts of the several control relays. Stages B, C, D, E and F each have associated therewith a control tube 110, 111, 112, 113 and 114 respectively, and each adapted to function in accordance with the corresponding ranges of output voltage from the computer.

For purposes of brevity, only the explanation of one stage will be given, the other functioning in the same manner, except for the voltage levels transmitted to each to cause the operation thereof. Stage B comprises a control tube 110 having a control grid 115, anode 116, and cathode 117. In the anode 116 of tube 110, there is connected a relay 118 responsive to current flow in tube 110 to cause the operational movement of contact arm 119 from contact 120, to contact 121. Before tube 110 can conduct, the voltage 102 from computer 101 must attain a D.C. level sufficient to overcome the fixed bias potential placed on the control grid 115 via biasing potentiometers 125, 122, 124 and 123*a*.

To set this operating level a general potentiometer 125, 122, 124 is provided to give a total range of bias voltage corresponding to the total voltage volume range of the output on 102. Across the general potentiometer, five individual potentiometers 123*a*, 123*b*, 123*c*, 123*d*, 123*e* are provided to give overlapping adjustability of the respective transfer points between voltage ranges or volume segments A, B, C, D, E and F.

For the A–B transfer control shown in detail as an example of all, the arm of potentiometer 123*a* is set to a voltage bias level corresponding to the volume level at which the A–B transfer is desired. When the positive voltage on the line 102 is equal to or greater than the negative voltage on the arm of potentiometer 123*a*, the voltage of the junction of resistors 134, 137, comprising a voltage divider between 102 and 123*a*, will go to approximately zero or slightly positive. This junction is connected to the control grid 115 and this causes the tube to pass sufficient anode current to operate relay 118 (BR) under these conditions, i.e. when the voltage on 102 exceeds the selected value for the A–B transfer.

Each of the stages have their control grids set at some fixed bias potential to permit the conduction of each of the control tubes only after a predetermined voltage level, indicative of the traffic volume, has been attained.

To assure rapid switching from one volume range to another, relay 118 must function with quick positive action. To enable such quick positive action there is provided in the control grid circuit a resistive and capacitive network designed to assure very heavy conduction of the control tube 110 at the time when the voltage level reaches the end of A volume range and the start of the next higher volume range B. FIG. 9 shows graphically the input signal voltage, or computer output voltage over the various volume ranges, represented by volume ranges A, B, C, D, E and F, and the points of transition *a′*, *b′*, *c′*, *d′* and *e′* for each of the respective ranges at which points the relays 118, 126, 127, 128, and 129 are made to function in response to heavy conduction of each of the control tubes associated therewith.

In operation, with respect to stage B, the biasing voltage of the grid 115 is sufficient to render the tube nonconductive up to and including all computer output voltages in the A range. However, when the computer output voltage exceeds the A-range voltage by an incremental amount, switch SWB1 will operate. Switch SWB1 comprises a network of resistors and condensers in the grid control circuit for the purpose of producing at the grid a large positive signal at the transition point *a′*. This is accomplished as follows; when the computer output voltage and the grid bias are substantially equal, tube 110 will commence to conduct, thereby causing relay 118 (BR) (normally de-energized) to operate. There is associated with relay 118 another set of contacts 130 and 131 and a contact arm 132. When relay 118 is de-energized, contact arms 119 and 132 are engageable with contacts 120 and 130 respectively. When the relay however is energized, the said contact arms become operably engageable with contacts 121 and 131 respectively. To provide for fast switching, contacts 131, 132 and 130 are arranged in a make-before-break sequence. While this does not show as such on the drawing, the adjustment is such as to produce a make-before-break.

Accordingly, when contact arm 132 and contact 131 are engageable, capacitor 135 shorts out momentarily the resistor 134, thereby producing as a result a large positive going pulse at the control grid 115; thus assuring that control tube 110 conducts heavily and relay 118 is given sufficient current to pull in positively.

Similarly when relay 118 has been energized, but the grid voltage falls below the level for the relay to stay in, the contact arm 132 will engage contact 130. The capacitor 136 will then short out momentarily the resistor 137, thereby producing at the control grid 115 a large negative going pulse thus assuring a sharp reduction in anode current to cause the relay to drop out cleanly.

By the resulting switching of the switch circuits in each of the output stages, there is produced at each of the control tube grids either a large positive or negative pulse, the produced pulses thus assuring the absolute presence or absence of relay energizing current to effect a sharp transition from one volume range to the adjacent volume range.

Resistors 133 and 138 serve to discharge capacitors 135 and 136 respectively when the relay BR is in the de-energized and energized positions respectively in preparation for switching. These resistors are large compared to resistors 134 and 137.

Associated with each of the output stages are a series of output terminals 140 through 145 inclusive and a series of lights 146 through 151 inclusive respectively, associated therewith. The output terminals are each selectively connected to the A.C. power source 103 whenever a particular relay circuit is energized to effect the operation of some external pieces of equipment, such as elapsed time indicators to indicate the total number of operation hours of the facility in any six preselected volume ranges, for example, or for recording graphically the time in different ranges for example.

As an alternative arrangement it is obvious that elapsed time meter or event recorders could be connected effectively to operate with the respective relays 118, 126–129 by means of additional make contacts on the latter to provide cumulative output or recording of traffic at and below each level.

When relays BR through FR are de-energized an uninterrupted series circuit from the A.C. power source 103 to the output terminal 140 is connected by virtue of the normally closed connections of contact arms 119, 161, 164, 167 and 170 to the respective contacts 120, 160, 163, 166 and 169. Upon energization of relay 118 (BR), contact arm 119 disengages contact 120 and engages contact 121, thereby disconnecting the output terminal 140 and connecting the output terminal 141 (B) to the A.C. power source.

In a similar manner each of the remaining output terminals may either be connected or disconnected from the A.C. power source depending upon whether the particular relay circuit associated with a particular output terminal is either energized or de-energized, the terminals only being connected one at a time.

The computer voltage output 102 is also fed to indicator meter 175 through a calibration resistor 176, to indicate the average volume of the vehicular traffic, and also to a graphic type recorder 92 for visual recording.

Now referring again to FIG. 1, the composite signal 60, comprising both speed and volume vehicular traffic information, from a typical traffic sampling station was transmitted via appropriate transmission facilities to a typical remote sampling station monitor 70. At the monitor station the resolver 71, as previously explained, separated the speed and volume frequencies indicative of the speed and volume of the sampled traffic conditions.

Referring to FIG. 7 the composite signal is transmitted to an amplifier 76 and subsequently filtered by a low pass filter circuit 180 composed of pie-sections with L1 and L2 as the series arms and C1, C2 and C3 as the shunting or parallel arms. The pie-section filter 180 is designed to pass all signals having frequencies below 1000 cycles, those above 1000 being substantially cut-off.

Therefore, the speed Doppler beat note in the range from zero to about 730 cycles will be passed by the filter and ultimately transmitted to the speed signal processing equipment which consists of a speed translator 181, speed indicator 182 and speed recorder 183 at the monitor station. Speed translator 181′, speed indicator 182′ and speed recorder 183′ at the sampling station may be similar to the corresponding units 181, 182 and 183 at the remote monitor station. The units 181′, 182′ and 183′ at the sampling may be omitted if local speed indication or recording at the sampling station is not desired. The speed translator can be generally of the type described in my U.S. Letters Patent No. 2,629,865 issued to Eastern Industries, Incorporated as assignee or in the Manual for Electro-Matic Radar Speed Meter, Models S–2 and S–2A issued and copyright 1955 by Eastern Industries, Inc., which latter form of speed meter is the subject of a co-pending application by me.

More specifically, and referring to FIG. 4*b*, the speed Doppler beat note 23*a* emanating from the speed sensing detector 20 is transmitted to amplifier 184 where the 0–730 cycle speed signal is amplified, then limited by amplitude limiter 185. To assure that sufficient amplification is always available to cause limiter 185 to perform properly, and to further suppress some signals which are not of sufficient magnitude to give a clean speed indication and to take care of slight decreases in signal amplitude which may cause the frequency counter 186, to which the limiter output is connected, to lose its count, a clamping circuit is provided, which comprises a clamp amplifier 187 and clamp 188, and connected to the limiter 185 input to shunt a part of the signal output of amplifier 184 when clamped, as by a voltage divider circuit for example, not shown herein. The clamp is controlled by the clamp amplifier 187 from the limiter 185, so that when sufficient signal has been received by the limiter-amplifier circuit 185, when clamped, to provide a clean speed reading, if unclamped, the clamp action of the clamping circuit responds, to decrease the shunting effect of the clamp on this signal output of amplifier 184 and thus to automatically increase the signal input to the limiter-amplifier 185, and thus the circuit becomes unclamped.

This same clamp and clamp amplifier circuit, after the target has passed, again reduces the gain of the amplifier automatically until such time as another target produces a signal of sufficient magnitude to give a clean speed reading.

The speed pulse signals from limiter-amplifier 185 are fed to a frequency counter 186 which produces an output voltage varying linearly with the frequency of the speed signal fed into it. The linear output voltage, indicative of the speed of the moving vehicle, is then amplified by output amplifier 189. The output of the latter is supplied to a meter indicator 182′ which measures the speed directly in miles-per hour and to a speed recorder 183′ for graphically storing the speed information. In the case of the corresponding speed translator 181 of FIG. 7 the output as supplied to meter indicator 182 and speed recorder 183 at the monitor station.

It will be noted that in FIG. 4*b* certain elements are shown to provide outputs to a low speed alarm and high speed alarm, these elements comprising the take-off line 250 feeding the speed signal at the limiter 185 input also to the low-pass filter 251 and high-pass filters 253. The output of the low-pass filter is fed to amplifier detector 252 to provide at output 256 a relay operating voltage indicating excessively low speed, as determined by the low frequency pass of the filter which may be adjustable.

Similarly the high pass filter 253 supplies its output to amplifier detector 254 to provide another relay operating voltage at its output 257 to indicate excessively high speed as determined by filter 253 which also may be adjustable. These outputs 256 and 257 control alarm relays such as shown in FIG. 2*a*, for example, the low speed relay LR particularly being of a slow acting type to avoid response to any transitory low frequency signal from the cosine effect as a high speed vehicle passes through a side part of the radio energy beam for example, at a maximum angle to the beam BE1–BE2.

These elements 250 through 257 are shown for convenience in FIG. 4*b* but would ordinarily be provided, when the low speed or high speed alarm features are desired, only at the remote monitor station, where the traffic supervisory personnel would be located for observation of the traffic conditions indicated or recorded. Thus these elements 250–257 would ordinarily be provided, when such alarm features are desired, only in the speed translator 181 at the monitor station 70 or 200 and not in the speed translator 181′ at the sampling station.

It will be obvious that the low speed alarm or high speed alarm might be omitted if desired, along with the associated elements in the 250–257 group.

The above substantially shows how supervision or surveillance of traffic conditions at a particular sampling area along a given highway facility is obtained and maintained. However, where a considerable expanse of highway facility is to be covered there must of necessity be a larger number of traffic sampling points or stations to properly monitor the traffic situation thereat.

FIG. 2 shows a typical dual twin-lane highway facility with a central or separation strip island between eastbound and westbound traffic as indicated by the directional arrows E and W respectively, with a series of spaced sampling stations along each twin-lane roadway, i.e. the east and west drives, on lanes CE and DE and lanes AW and BW respectively, to obtain at the particular sampling location traffic information as to speed and volume. The information is then relayed, from each of the spaced sampling stations, to a remote central monitoring station 200.

FIG. 2 illustrates a simplified arrangement by which speed information for example from the several sampling stations may be transmitted directly to corresponding monitor indicators and associated recorders at the central monitoring station. When speed information alone is to be transmitted and indicated, the composite mixer 24 and associated resolver 71 of FIG. 1 may be omitted and the speed signal transmitted directly from the speed sensing detector 20 at 23*a* of FIG. 4*a* to the corresponding monitor indicator of FIG. 2 which may include the speed translator 181 of the type illustrated by translator 181′ of FIG. 4*b*, along with the speed indicator 182 of FIG. 1 and FIG. 7. The recorder when included may correspond with recorder 183 of FIG. 1 and FIG. 7.

Thus in FIG. 2 for each sampling station traffic detector there is a corresponding monitor indicator and its associated recorder at the central monitoring station, and from one central point, traffic conditions from a plurality of sampling points may be properly observed and recorded and appropriate steps taken to correct any abnormality which may develop either immediately, due to some accident, or over a prolonged period of time. In the preferred form of the central monitor station, there is further provided at each of the monitors for mounting at each representative monitor an alarm indicator mechanism for setting into operation an alarm to indicate when the traffic volume and/or speed of moving vehicles at or along a particular sampling station either exceeds or falls below certain predetermined levels.

As illustrated in FIG. 2, the representative monitor indicators are each provided with indicator lights (L) and (H) to indicate that the speed or volume is low or high, or below a predetermined level or above another predetermined level respectively. Therefore, for example, if the traffic speed at sampling station 1E falls below the preselected level, the light L on monitor indicator 1E′, will be illuminated and a common alarm bell 212 will ring to indicate such abnormality. The alarm circuits are provided with a release pushbutton or switch PB associated with each monitor indicator for resetting the alarm, and shown between the L and H lamps.

The common bell or buzzer alarm gives the supervisory personnel a warning that something at one of the sampling stations is amiss, and one or more of the indicator lights (L) or (H) on the monitor indicators will glow to show which of the sampling stations, and therefore the location, where the particular abnormal condition exists.

A 24 hour clock and date indicator is also shown in the central monitoring station adjacent the monitor indicators for example, along with a place designated "NOTES" for writing notations of data for photographic recording purposes if desired.

FIG. 2*a* shows one form of alarm circuit arrangement, for the alarm bell and low and high indicator lights L and H of FIG. 2. Only two sets of circuits are shown for the 1E′ and 2E′ monitor indicators respectively, since these circuits are representative of all, each circuit having a low level alarm relay LR and a high level alarm relay HR for operating the respective lamps L and R associated with its own monitor indicator, and also for operating the common bell or buzzer alarm 212. It will be noted that the bell operating circuit extends to the several lower contacts of the several LR and HR relays in parallel, with extensions for connections to corresponding relay contacts for the 1W′, 2W′, 3W′ and 3E′, etc. monitor indicators so that operation of any relay will also operate the common bell.

Considering the alarm circuit for 1E′ more fully as representative the low and high speed operating voltage inputs 231 and 232 for example enter at the left and right at the foot of the figure from the associated speed translator low speed and high speed outputs 256 and 257 respectively, and extend to the LR and HR relay coils respectively in parallel with the associated lamp, L for LR and H for HR, the upper sides of the lamps being returned to the negative power terminal or ground. The other sides of the coils of relays LR and HR extend to such negative power terminal via a normally closed pushbutton or switch PB common to the associated pair of relays LR and HR for 1E′. The upper contacts of these relays provide lock-in or holding circuits for the relay and associated lamp, so that the particular relay once energized by incoming operating voltage (positive) on its input line, will remain energized over its upper contact along with its lamp and will also energize the common bell, until the release switch PB is opened manually for example by the observer, upon which the particular relay lamp and common bell are all released.

Where the alarm circuitry of FIG. 2*a* or additional similar alarm circuitry is employed for low and high traffic volume the input circuits may be connected with output circuits of volume level classifier of FIG. 8*b*, such as 140 for low and 145 for high for example.

It can be appreciated that the central monitoring station may not need a monitor indicator corresponding to each of the sampling stations. Rather, as shown in FIG. 3, a central monitoring station 214 may be provided with a selective switching system whereby only a limited number of representative monitors 215, 216 and 217 and an equal or fewer number of recorders 218 and 219 are installed. By the appropriate setting of the selector switches 220, 221 and 222 a particular monitor may be selected to function with a particular sampling station. Also by the appropriate setting of each of the recorder selector switches

223 and 224, a recorder may be selected to function with a particular monitor.

Although FIG. 2 shows a simplified arrangement for centralized monitoring of a number of individual sampling stations along a highway facility particularly for speed information, it will be understood that it also serves diagrammatically to illustrate such centralized monitoring of volume information, or speed and volume information together, from the several spaced sampling stations. It is obvious that a plurality of sampling stations and associated remote monitor stations of the type shown in FIG. 1 in block form, and in FIGS. *4a–4b*, *5a–5b*, FIG. 7 and FIG. *8a–8b* in more detailed form, may be arranged with closely adjacent monitor indicators, and with alarm features as desired in the general form of FIG. 2, with monitor indicators including both speed and volume indications. Similarly the recorders of the central monitoring station 200 of FIG. 2 may be dual or doubled for recording both speed and volume.

For obtaining speed and volume information the blocks indicated as "TRAFFIC SPEED DETECTOR" in FIG. 2 would include traffic speed and volume detectors, and may transmit the outputs directly over individual channels or by means of the composite mixer and resolver feature as in the preferred form.

It will be understood that in some instances the volume meter 175 of FIG. *8b* and/or recorder 92 may be included in the central station 200, without the volume level classification feature of FIG. *8b*, but where the output circuits of the latter are desired for control of high and low alarm circuits as volume alarms, this volume level classification feature would be included to permit the low and high volume alarms to be operated by output circuits 140 and 145 respectively for example.

As a further alternate arrangement some of the sampling stations and remote monitors of FIG. 2 might give speed alone and others volume alone, either by alternating adjacent spaced sampling stations or otherwise.

It will also be understood that the spacing between the spaced sampling stations may be uniform in some installations, or may be varied in other installations in accordance with the characteristics of the different sections of the highway facility. Thus in sections of more than two lanes in each direction or having shorter range of visibility or other physical or expected heavy or generally slower traffic conditions the sampling stations might be more closely spaced than on more open or straight or generally lighter traffic or normally higher speed sections, for example. Such spacing may vary from somewhat less than one mile to a number of miles, depending on the degree of coverage desired, for example. The sampling station locations might in some instances be related to entrances and exits or traffic interchanges on the highway facility.

Although the invention has been described and illustrated in several aspects of remote traffic supervision and in a preferred form having both indicating and recording and also having alarm circuits for high and low traffic conditions, it will be appreciated that under some circumstances sub-combinations of features such as by indicating without recording, or by recording without separate indicating, or by recording or indicating without classification into several volume levels will have individual value, as may also the remote contralized monitoring of speed alone at appropriately spaced stations. In the latter connection it will be appreciated that one stationary sampling station samples the speed of more traffic units than a patrol officer on mobile patrol moving with the traffic, and that sampling at spaced points of known distance and approximate travel time at any particular speed together with providing the traffic speed information at closely adjacent and identified points as on a panel at the centralized monitor station, enables comparison of conditions at the spaced points by the traffic supervisory authority, quickly and as continuously as desired.

The volume sensing detectors 1 and 2 of FIG. 1 may for example, be of the type disclosed in the Manual for Model RD–1 and RD–1A Radar Vehicle Detector copyright 1956 by Eastern Industries, Inc., which is the subject of a copending application by me.

The remote or centralized monitoring station may be at police patrol headquarters or other traffic supervisory location where radio communication may be had with mobile patrol for example.

Several aspects and forms of the invention have been pointed out above and illustrated in the drawings, and it will also be appreciated that various further modifications or rearrangements of the illustrated or described embodiments of the invention or in parts thereof may be made without departing from the spirit of the invention within the scope of the appended claims.

I claim:

1. A traffic surveillance system for surveying vehicular traffic speed and volume conditions over a highway facility and comprising
 - a traffic sampling station having
   - vehicular speed and passage detection apparatus for producing electrical signals indicative of the speed and passage of moving vehicles,
   - means for combining the speed and passage signals to produce a composite electrical signal, said combining means including
     - make-before-break relay circuit means activated responsive to the said passage sensing detection apparatus output signals,
     - oscillation means operably responsive to the activated relay means for producing an oscillatory signal output,
     - and output circuit means for receiving the oscillatory signal indicative of the traffic passage and the speed signal indicative of the vehicle speed and producing therefrom the output composite electrical signal,
 - means for transmitting the composite electrical signal along a pre-determined transmission path,
 - a remote sampling station monitor for receiving the transmitted composite electrical signal and comprising
   - a signal resolver for receiving and resolving the composite signal into the traffic passage electrical signals and speed electrical signals,
   - means for receiving the speed electrical signals and producing a voltage therefrom proportional to the speed of the moving vehicles,
   - means responsive to said voltage for producing a visual speed indication,
   - means for receiving the passage electrical signals and producing a further voltage therefrom proportional to the traffic volume level of the moving vehicles,
   - and means responsive to said further voltage for producing a visual traffic volume level indication.

2. A traffic surveillance system according to claim 1 and wherein the said oscillation means includes a relaxation oscillator having an electron tube control electrode biasing means operably responsive to the actuation of the make-before-break relay means and causing the oscillator to generate oscillations in accordance with the said actuations, and the output circuit means includes an amplifier having a pair of input stages and an output stage and whereby the said oscillations are fed to one of the input stages and the speed signal is fed to the other input stage, the said signals appearing at the output stage as a composite signal.

3. A traffic surveillance system according to claim 2 and wherein the said control electrode biasing means of

the relaxation oscillator includes a chargeable capacitor charged through the said control electrode to maintain the oscillator non-conductive by virtue of the bias thereon and adapted to be discharged by the relay means when the said relay means is actuated and thereby removing the bias and causing the oscillator to conduct.

4. A traffic surveillance system for surveying vehicular traffic speed and volume conditions over a highway facility and comprising

a traffic sampling station having

vehicular speed and passage detection apparatus for producing electrical signals indicative of the speed and passage of moving vehicles,

means for combining the speed and passage signals to produce a composite electrical signal,

means for transmitting the composite electrical signal along a pre-determined transmission path,

a remote sampling station monitor for receiving the transmitted composite electrical signal and comprising

a signal resolver for receiving and resolving the composite signal into the traffic passage electrical signals and speed electrical signals, said resolver comprising

an input circuit for receiving a composite signal consisting of vehicular traffic passage and speed indicative signals and

a pair of output circuit means for separating the passage and speed signals and including

a low pass filter circuit for discriminating against all frequencies above a pre-selected cut-off frequency

and a tuned circuit tuned to a pre-selected fixed frequency outside the low pass filter pass band, the low pass filter substantially passing all indicative speed signal frequencies and the tuned fixed frequency circuit passing only the indicative passage signal frequency,

means for receiving the speed electrical signals and producing a voltage therefrom proportional to the speed of the moving vehicles,

means responsive to said voltage for producing a visual speed indication,

means for receiving the passage electrical signals and producing a further voltage therefrom proportional to the traffic volume level of the moving vehicles,

and means responsive to said further voltage for producing a visual traffic volume level indication.

5. A traffic surveillance system according to claim 4, and wherein one of the output circuit means includes signal detection means adapted to receive the vehicular traffic passage signals and produce an output passage signal pulse therefrom and relay means including a normally inoperable output circuit amplitude responsive to the reception of the output passage signal pulse to effect the operation of the output circuit.

6. A traffic surveillance system for surveying vehicular traffic speed and volume conditions over a highway facility and comprising

a traffic sampling station having vehicular speed and passage detection apparatus for producing electrical signals indicative of the speed and passage of moving vehicles,

means for combining the speed and passage signals to produce a composite electrical signal,

means for transmitting the composite electrical signal along a pre-determined transmission path,

a remote sampling station monitor for receiving the transmitted composite electrical signal and comprising

a signal resolver for receiving and resolving the composite signal into the traffic passage electrical signals and speed electrical signals,

means for receiving the speed electrical signals and producing a voltage therefrom proportional to the speed of the moving vehicles,

means responsive to said voltage for producing a visual speed indication,

means for receiving the passage electrical signals and producing a further voltage therefrom proportional to the traffic volume level of the moving vehicles,

and means responsive to said further voltage for producing a visual traffic volume level indication, the said volume level indicator means including a plurality of volume range switching means each having an output circuit associated therewith and each of said plurality of volume level range switching means responsive to a different signal amplitude level therefor indicative of the vehicular traffic volume level over pre-selected traffic volume ranges, each of said output circuits individually operable in response to the operation of its associated volume level range switching means,

and means connecting said output circuits for selectively providing a single output at only one of said output circuits in response to different selective signal amplitudes.

7. A system according to claim 6, and wherein the volume level range switching means includes switching electron discharge devices normally nonconductive and each having an input and an output circuit means therefor, each of said input circuit means individually responsive to a different signal amplitude level indicative of the vehicular traffic volume level over preselected traffic volume level ranges causing the electron discharge device to conduct to produce in the output circuit means indicative volume level signals over the pre-selected volume level ranges.

8. A system according to claim 7 and wherein the output circuit means comprises a relay operably responsive to the conduction of the discharge device and output terminal means for receiving volume level signals in response to the operation of the relay, and the input circuit means comprises a pair of selective networks one adapted to cause the rapid conduction of the discharge device in response to the energization of the relay and the other adapted to cause rapid cut-off of the discharge device in response to the de-energization of the relay to effect rapid volume level range switching from one traffic volume level range to an adjacent traffic volume level range.

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