United States Patent

[11] 3,626,413

[72] Inventor Howard C. Zachmann
2832 Montclair Drive, Ellicott City, Md. 21043
[21] Appl. No. 7,586
[22] Filed Feb. 2, 1970
[45] Patented Dec. 7, 1971

[54] **TRAFFIC SURVEILLANCE AND CONTROL SYSTEM**
20 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** .... **343/8,** 235/150.24, 343/6 A, 343/9
[51] **Int. Cl.** **G01s 9/44,** G06f 15/48
[50] **Field of Search** .... 343/6 A, 8, 9; 235/150.24

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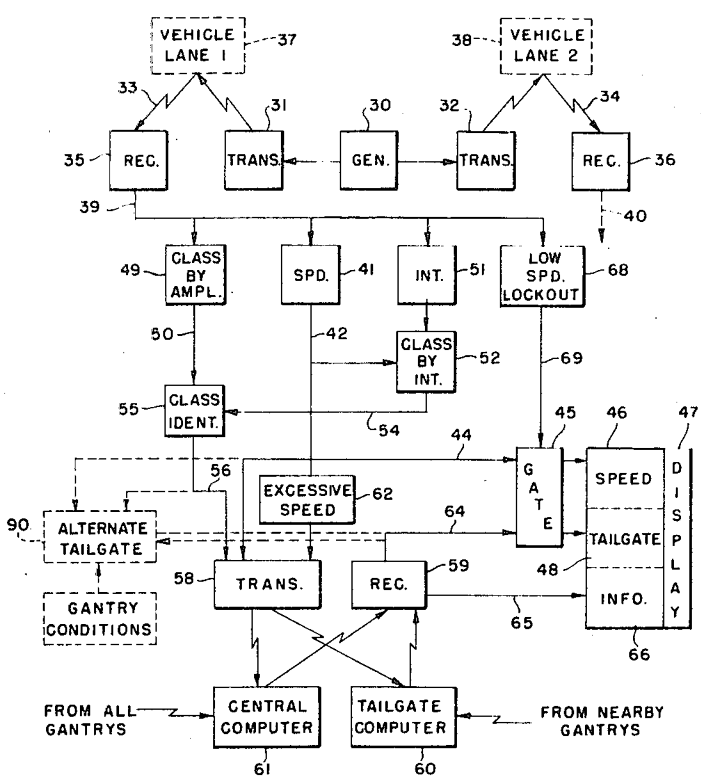
Primary Examiner—Malcolm F. Hubler
Attorney—Sughrue, Rothwell, Mion, Zinn & Macpeak

ABSTRACT: An all-weather system utilizing doppler radar devices for monitoring traffic on highways to provide warnings and diversionary information to motorists. Radar equipment mounted on gantries at selected locations along the highways provides traffic information on the number, type and velocity of vehicles and together with complementary equipment such as a data-linked computer develops information on traffic density and required clear distance for trailing vehicles, continuously taking into account local environmental conditions. The latter "tailgate" information as well as velocity and diversionary information is provided at the gantries as a visual display. Counting of vehicles by class is performed both by doppler pulse amplitude and interval at a monitored speed techniques and two alternate configurations for providing the tailgate function are disclosed, one being completely self-contained at the gantry.



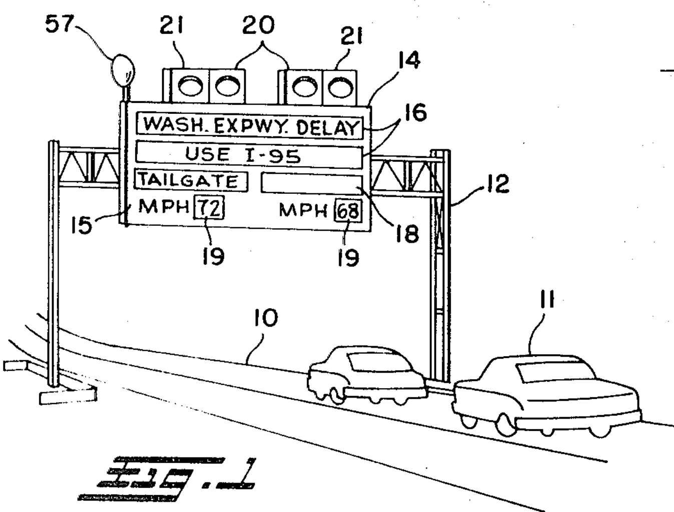


FIG. 1

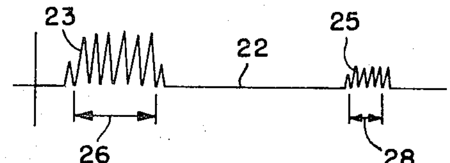


FIG. 4A

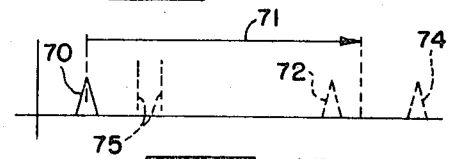


FIG. 4B

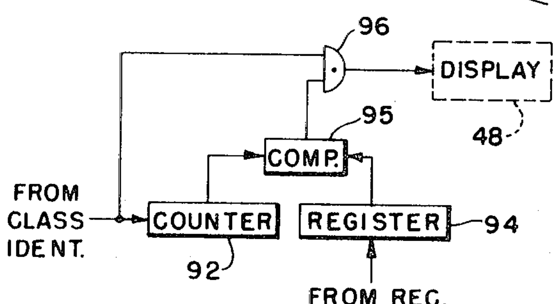


FIG. 5

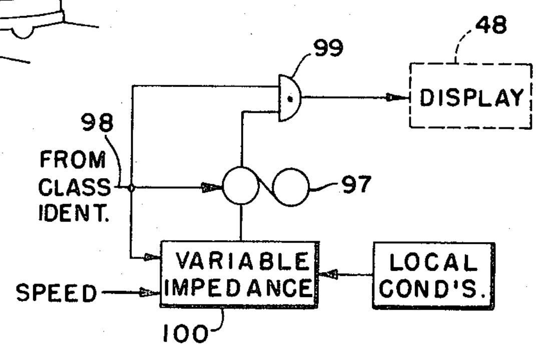


FIG. 6

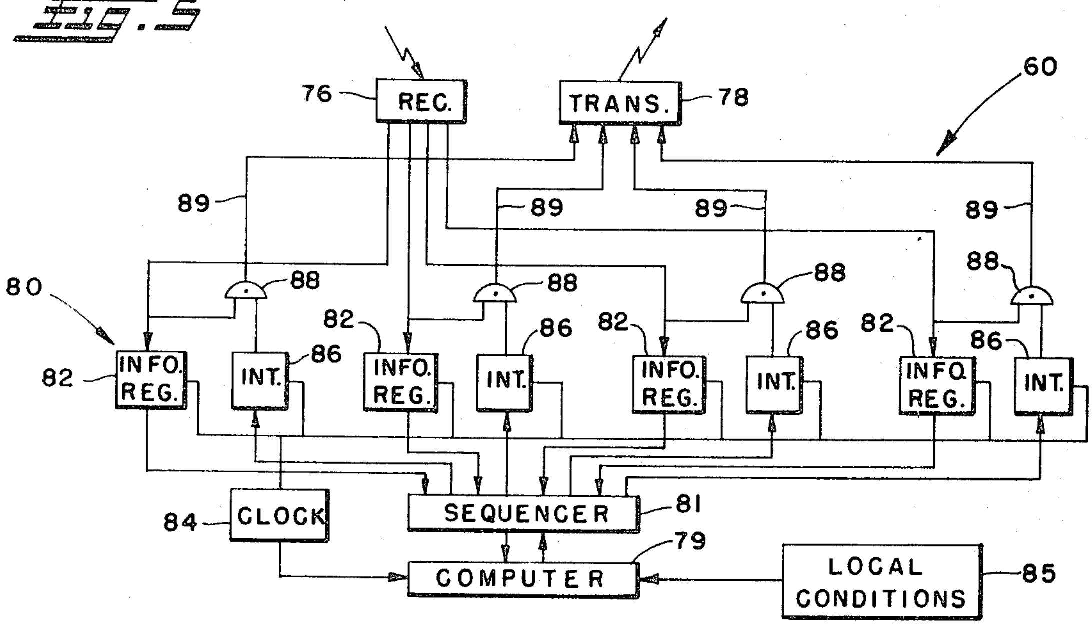


FIG. 3

INVENTOR.
HOWARD C. ZACHMANN
BY
Oberlin, Maky, Donnelly & Renner
ATTORNEYS

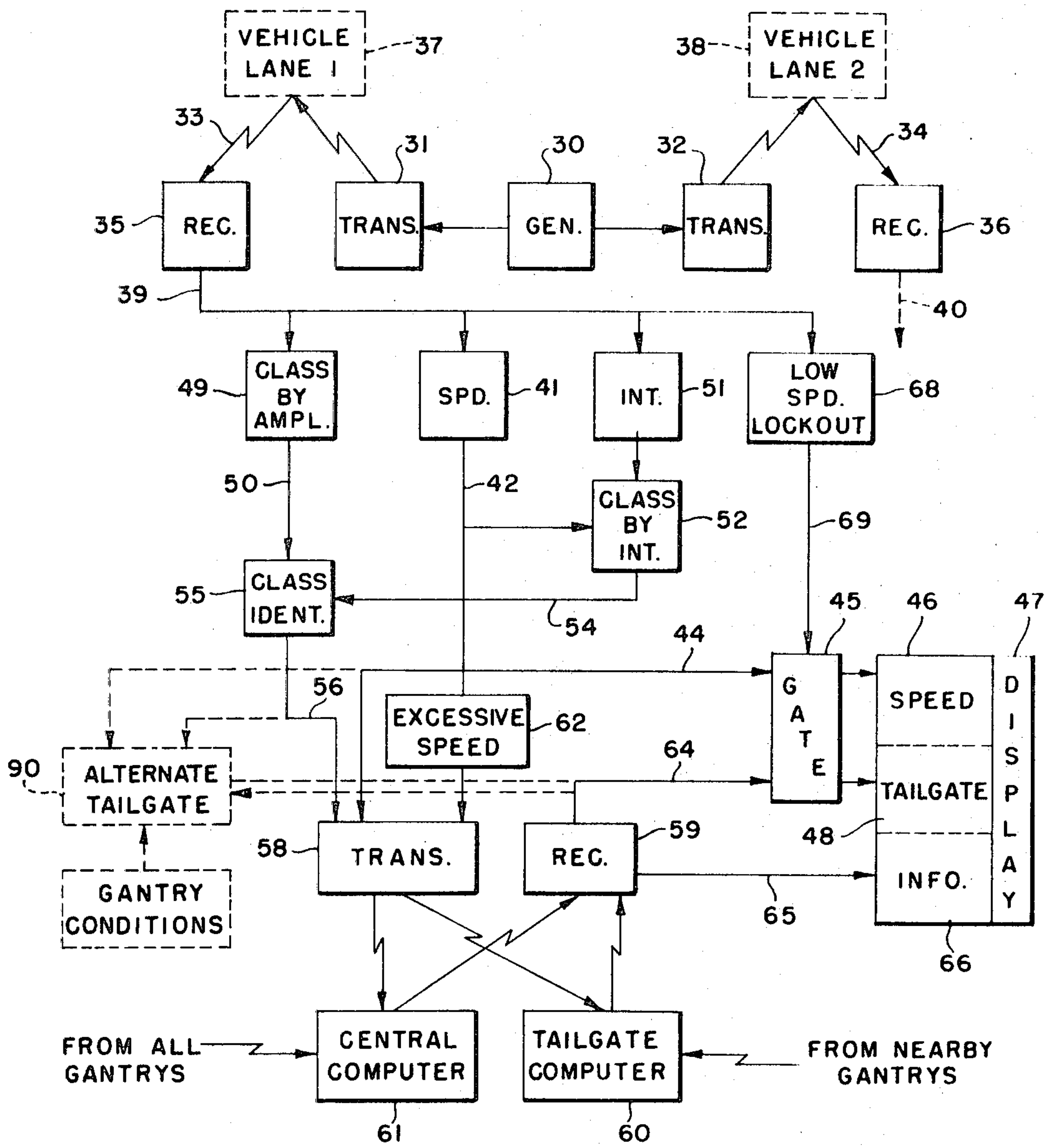


FIG. 2

INVENTOR.
HOWARD C. ZACHMANN
BY
Oberlin, Maky, Donnelly & Renner
ATTORNEYS

TRAFFIC SURVEILLANCE AND CONTROL SYSTEM

This invention relates to traffic monitoring and motorist assisting systems and more particularly to a system operating on the doppler principle which provides a segregation of trucks and pleasure cars and performs a computation upon the data received to provide useful traffic information in a visual display for immediate aid to the motorist as well as a tabulation of such traffic data at a central control station for statistical surveys, and traffic control in real time.

While much consideration has been given to the surveillance of traffic flow on the principle of apprehending traffic offenders as well as obtaining knowledge of highway use and efficiency, little consideration has been given to supplying meaningful information to the vehicle operator so that he can make his own decision as to routes of preference and the like as well as to provide a continuous monitor of his vehicle operability characteristics.

It is well known in many of the present day highway systems that saturation conditions often exist and that motorists endure such situations even though alternate routes exist. While little effective results can be obtained with variations in the interstate traffic patterns, most of the traffic around urban areas of the country comprises operators who are generally familiar with alternate routes of travel and who would avail themselves of same if sufficient information were provided of congested areas and traffic flow patterns which are outside their range of recognition.

It is also well known that the high velocities of vehicle operation on today's highways are a major factor in causing accidents and traffic congestion, not only from a failure of mechanical equipment but more so from a lack of education and familiarity of the greatly changed conditions occurring not only at the different rates of speed but also under the varying environmental conditions. A recent survey has indicated that a six fold increase in traffic mishaps accompanies each 10 mile per hour increment of parallel vehicles velocities and it is well known that accident rates are accentuated under poor environmental conditions such as the change from day to night and vice versa and the sudden encroachment of fog or other adverse weather conditions.

While it is not suggested that supplying certain information to the motorist will obviate all traffic mishaps nor that it is practical to supply all possible information to the operator, it is clear that certain fundamental data would be extremely invaluable as a check upon the operating characteristics of the individual vehicle as well as an instruction as to its proper operation, and would provide the advantages of supplying information on environmental conditions and traffic flow patterns beyond the operator's area of immediate concern. The typical original equipment speedometer in most vehicles is an instrument highly subject to error both from a mechanical design standpoint and the influence of tire wear and environmental factors so that an overall accuracy of approximately 10 percent is not considered unusual. It would be beneficial to advise the operator from time to time of an extremely accurate appraisal of his operating velocity and instrument error both for his own personal benefit and for his influence upon other traffic in the vicinity.

The tailgating information has been conspicuously absent in the past requiring a complicated evaluation not only of a particular vehicle's velocity and type, but also of the characteristics of the environment at a particular location. While vehicle braking figures have been published in the past and guides have been given as to the proper operation of vehicles at various highway speeds, such as for example recommending a certain multiple of car lengths separation for different speeds of operation, such information is easily forgotten or if retained is difficult to apply realistically under driving conditions. Further, many people choose to ignore such guidelines preferring to depend instead upon their own evaluation of the driving conditions and their enhanced estimate of speed of reaction and vehicle capabilities. The rapid calculation of an almost instantaneous display of such encroachment upon the minimum safe distance behind a moving vehicle would provide an essential piece of information for the concerned driver and a signal of warning to those in the immediate vicinity. Further, such information can be invaluable as an aid in signalling an unrecognized approach into a dangerous condition causing an immediate response in the operator of the vehicle similar to the sudden illumination of a stop light in the vicinity.

Still further, while all drivers realize the convenience and desirability of having a well marked highway wherein alternate routes and approaching conditions are displayed, little attention has been given in the past to providing a highly versatile and refined system which can supply any form of desired information to the operator from instructions developed at a central control station.

Therefore it is one object of this invention to provide an improved traffic control system which provides general information to all traffic in a particular vicinity and specific information to individual vehicles in a lane of traffic.

It is another object of this invention to provide an improved traffic surveillance and control system which operates on the doppler principle for measuring vehicle velocity and utilizes the same received signals to discriminate among the various classes of vehicles.

It is yet another object of this invention to provide an improved traffic control system which senses definite characteristics of vehicle movement and operates in conjunction with a computer to provide information to the operators, calculated as a function of such data and the environmental conditions existing at that instant.

It is still another object of this invention to provide an improved traffic control system which provides a visual indication of the presence of a vehicle within a calculated unsafe distance behind a preceding vehicle.

It is a still further object of this invention to provide an improved traffic control system which operates to gather information on a per lane basis as to vehicle class, velocity and tailgate encroachment and accumulates this data on a lane, highway or traffic system basis to provide statistical data as to density of vehicles, flow rates of movement, and efficient use of highway systems.

Other objects and advantages of the present invention will become apparent as the following description proceeds.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but one of the various ways in which the principles of the invention may be employed.

In said annexed drawings:

FIG. 1 is an environmental view of a portion of a highway system showing a single gantry for monitoring traffic on a dual lane highway and for providing visual information;

FIG. 2 is a block diagram of the logic of the system for surveying and controlling traffic in two adjacent lanes;

FIG. 3 is a block diagram of the preferred embodiment of the tailgate computer depicted in FIG. 2;

FIG. 4A is a curve showing a typical response characteristic from moving vehicles as received at the radar detector;

FIG. 4B is a timing graph showing the relation of pulse signals from trailing vehicles with the determination of the tailgate interval;

FIG. 5 is a first alternative embodiment for determining the tailgate function; and

FIG. 6 is a block diagram of a second alternative embodiment for determining the tailgate function wherein all circuit components are contained at each gantry.

Referring now to FIG. 1 there is shown an environmental view of a portion of a highway system which in this instance is a dual lane highway 10 having vehicles 11 moving therealong at varying velocities. Spanning the highway is a gantry 12 for support of a portion of the apparatus of the invention, the latter comprising a generally rectangular enclosure 14 centrally located above the lanes of the highway and comprising in part on the forward portion thereof a display board 15 for presentation of visual information to the motorists in the vehicles.

The display board 15 may be any one of many commercially available units but preferably is of the type which provides an illuminated display. The board 15 contains an area 16 to provide a variety of printed information at the upper portion thereof common to both lanes, and for each lane an illuminable tailgate indication 18 and digit indication 19 for providing a readout of monitored velocity of passing vehicles. Preferably there is sufficient separation between the displays for the individual lanes so that there will be no confusion of interpretation of data represented on the display board and as pointed out in greater detail hereinafter illumination of the signals will be sufficiently synchronized with movement of the vehicles beneath the display board so as to avoid misinterpretation of the information.

Also associated with each lane of the highway 10 and mounted above the housing 14 are the transmitting and receiving units 20, 21 for the radar signals which provide surveillance of the traffic on the highway. The radar system is of the conventional type for detecting the movement of traffic preferably operating in the range of from 8 to 12 gHz to provide the typical doppler spread of received frequencies which are proportional to vehicle speeds.

The radar transmitting and receiving units 20, 21 are preferably of the highly directional type and are aimed at a location down the highway 10 from which the vehicles 11 are moving at an angle from the horizontal sufficient to provide a suitable received signal from the vehicle while not creating too great a masking effect between trailing vehicles. Since it is desired to obtain two types of signals along with the doppler signal of frequency variation some compromise must be made between elevation of the transmitting and receiving units 20, 21 above the roadway surface and angular direction of same along the lane of traffic. The additional signals desired are a frontal surface reflection from the vehicles 11 providing a variation in amplitude of the received signal and an interval signal indicative of the length of time the vehicles 11 are exposed to the radar signals, the latter being related to the length of the vehicle.

A typical example of such received energy is depicted in FIG. 4A wherein a curve 22 includes a first burst 23 of reflected energy of relatively large amplitude and a second burst 25 of received energy at a later time of relatively small amplitude. Assuming some correspondence between the capability of an exposed area of a vehicle to reflect a quantity of energy proportional to such area, such difference in reflected amplitudes of received signals may be detected by a simple level detector circuit to provide discrimination among the various types of vehicles, providing information, for example, of the presence of passenger cars versus trucks.

It is significant to note also in FIG. 4A that the bursts of energy 23, 25 occur over different intervals, the interval 26 of the first burst 23 being substantially larger than the second interval 28 and being indicative of the time of receipt of reflected energy. Assuming the two vehicles which produce the bursts 23, 25 of energy were moving at the same velocity when monitored, then such bursts would be related to the times that the vehicles were in the beam area of the radar system to thus provide a measure of the overall lengths of the vehicles.

As is well known to those skilled in the art, the frequency of the received bursts 23, 25 is modified from the frequency of the transmitted signal as a function of the velocity of the vehicle and, by suitable detection circuitry, can provide a direct indication of such velocity. Thus upon receipt of an isolated burst of reflected energy, an immediate measurement of velocity of the vehicle can be performed and this information can be utilized in conjunction with the duration of receipt of the reflected signal to provide a discrimination between the various types of vehicles, in this instance providing a relative measure of the length of same and an indication, for example, of a truck or passenger car.

While no definite limits have been placed on the elevation of the radar devices 20, 21 above the roadway surface, it has been determined that an elevation of from 20 to 60 feet will provide the useful data in most environments and a figure of 30 feet of elevation may be adopted as nominal. Similarly the most useful angle of direction of the radar devices 20, 21 with respect to the horizontal appears to lie in the range of from 9° to 21°, and with an angle of 10° adopted as nominal produces approximately a 35 foot length of roadway sensitive to the radar signals at minus 3 db. beam levels, assuming a 2° beam width. With such nominal factors, approximately a ½-second echo signal is received from a vehicle passing through the sensing area at approximately 50 m.p.h.

Referring now to FIG. 2, there is shown in block diagram form the interconnection of components for a single gantry 12 capable of monitoring traffic flow in a pair of adjacent lanes of traffic as depicted in FIG. 1. Only the components for lane 1 are shown in full together with those components common to both lanes and it will be understood that such system is duplicated in part for a processing of information of the lane 2 traffic and may be expanded for any number of lanes of monitoring.

The components mounted at the gantry 12 include the radar generator 30 which is a conventional microwave generator operating in the range of 10 gHz and adapted to energize the radar transmitters 31, 32 for both lanes 1 and 2. Power for the radar generator 30 and the remainder of the components on the gantry 12 is obtained in any of the conventional manners preferably being energized from a nearby transmission line. The radar generator 30 is adapted to supply continuous signals to the transmitters 31, 32 so as to provide a continuous surveillance of the traffic conditions in both lanes and the echo or reflected signals, indicated by the arrows 33, 34 are recognized at the receiver units 35, 36 as bursts of high-frequency energy having the doppler frequency variation characteristic of the rates of movement of the reflecting vehicles 37, 38 along the highway, as graphically depicted in FIG. 4A.

The receiver units 35, 36 comprise minimally antennas sensitive to the microwave energy, being highly directional to receive only the desired signals from one lane and further may comprise amplifiers or demodulating units for combining the reflected signals with the signal of the radar generator 30 so as to produce sum or difference frequencies which contain the information characteristic of the vehicle movement. As indicated in FIG. 2, the output of the radar receiver 35 is applied to a plurality of components as indicated by the distribution line 39 and similarly the output of the receiver 36 for lane 2 is indicated as being applied to similar circuitry (not shown) by the dashed line 40.

The information on line 39 is applied to a speed module 41 wherein a computation is performed to provide an output on line 42 indicative of the instantaneous velocity of the vehicle 37. This computation can be performed directly from the information available in the received pulse, consisting generally of a frequency to voltage conversion. Preferably the output of the speed module 41 and other components are digitized into binary signals for information handling purposes and for compatibility with the computers and display board to be described, however, it is clear that the selection of the format of the signals within the system is primarily a matter of choice taking into account factors such as accuracy, economy and efficiency of operation.

The output of the speed module 41 is directed by way of line 44 to a gate module 45 and eventually to the speed indicating portion 46 of the display board 47 to provide a visual indication to the motorist while he is still in the range to view the information provided. It will be clear that additional holding and synchronizing circuitry may be incorporated in a system of this type for retaining the desired indications on the display board 47 for predetermined intervals so as to be available to the motorist and to avoid confusion of interpretation of the data by preceding or following motorists.

It is also desired to identify the class or type of vehicle 37 producing the reflected modulations, which information is useful not only for statistical surveys of the use of the highways, but also is significant in producing the tailgate display 48 as consideration is given to the different driving conditions effected with various types of vehicles.

The information on line 39 is applied to a circuit 49 identified as a class by amplitude discriminator which circuit 49 is effective to sense the various amplitudes of the received signal and categorize the same as indicative of the types of vehicles, ranging from the large signal received from a tandem trailer, for example, to the small amplitude signal received from a compact automobile. The discriminator circuit 49 may comprise simply a voltage level detector circuit providing a digitized output signal indicated at line 50 for application to further circuitry.

A second identification of vehicle classification is made on the basis of width of reflected signal, such circuitry comprising an interval sensor circuit 51 adapted to receive the output of the receiver unit 35 and functionally operative to convert the received signal to an indication in time. Such signal by itself is useful only at a known velocity of movement of the vehicles and therefore further circuitry identified as a class by interval discriminator 52 is utilized to convert the signal from the interval circuit 51 to a digitized output on line 54 as a function of the speed signal received from line 42. The output of the interval discriminator 52 is then in substantially the same format as the output of the amplitude discriminator 49 and both are applied to the class identification circuit 55 to provide an output, as at 56, identified as to class of vehicle, for each vehicle which is sensed. While the discrimination of vehicles by two separate systems of classification may be redundant in part, the additional sensitivity in definition provides a more accurate identification than is possible with either singular system. The class identification circuit 55 may simply comprise an AND gate combining circuitry for providing additional classifications of vehicles, or the input information may be combined in other manners to provide a partially redundant measurement for a smaller classification of vehicles, the only requirement for such circuit 55 being that of providing a single output in one of the specified classes which output can be accumulated as a count of the traffic occurring on the highway.

The components on the gantry 12 further include a data link unit 57 comprising a transmitter 58 and receiver 59 for the transmission and receipt of information both to a tailgate computer 60 which is operative to perform the tailgate function for a plurality of gantries located in a common area and to a central computer 61 for tabulation, further analysis and command information. The central computer 61 is remotely located and adapted to receive information from all gantry sensing stations in an area wide traffic control system, as for example, the complete traffic system associated with a particular city or area of the country. The transmitter 58 and receiver 59 of the gantry system depicted in FIG. 2 preferably comprise a microwave data link and are operative to act upon the information received both from the lane 1 and lane 2 components, preferably operating on a time sharing basis. As indicated, the output of the class identification circuit 55 and the output of the speed module 41 are applied to the transmitter 58 on lines 56, 42, together with auxiliary available information such as, for example, an excessive speed signal derived from module 62 adapted as a level detector to provide a pulse output whenever a nominal predetermined operating speed is exceeded.

The output of the receiver 59 of the data link is connected via line 64 through the gate 45 to the tailgate portion 48 of the display board 47 to provide, upon command from the tailgate computer 60, the visual indication to the motorists while still within the viewing angle of the board. Another output 65 of the receiver 59 is connected to the information portion 66 of the display board 47 providing the instructional and informative information for motorists assistance, such information primarily being received from the central computer 61, being manually entered by a traffic controller who can monitor a widespread area of the system and provide suggestions as to alternative routes or indications of traffic tie-ups and the like.

A further component of the gantry control system includes a low speed lockout circuit 68 which is effective to control the indications of speed and tailgating on the display board 47 by means of opening or closing the gate 45. The lockout circuit 68 is utilized under high density traffic conditions wherein very slow movement of vehicles is encountered due to an accident or traffic backup, the circuit comprising essentially a detector for sensing closely spaced pulse groupings on line 39 and operative to provide an on-off signal on output line 69. Under such conditions, the information on the display board 47, other than the general instructional information, is essentially useless and confusing to the motorists and calls for rapid response of the mechanism for changing the indications on the board.

The tailgate computer 60 is a general purpose digital computer programmed to determine an unsafe following distance behind any specific class of vehicle travelling at any velocity as a function of the local environmental conditions including weather conditions, the amount of daylight available, road surface conditions and the like. A preferred embodiment of the tailgate computer 60 depicted in FIG. 2 is shown in greater detail in FIG. 3 comprising components having sufficient capacity to handle the information supplied from a plurality of gantries in a localized area and preferably operative on a time sharing basis.

The function of the tailgate computer 60 is depicted in the graph in FIG. 4B wherein a timing diagram is shown of the receipt of information from a single line of traffic, a pulse 70 occurring at the initial portion of the graph indicating the presence of a specific form of vehicle moving at a known velocity. It is desired to calculate instantaneously a distance related to such vehicle which would be dangerous for a trailing vehicle to encroach, based on knowledge of good driving practices, vehicle mechanical capabilities and speed of human response. It is also desired to modify such distance calculation as a function of the environmental conditions existing at the time, including the weather, available light and road surface conditions. For ease of information handling this distance can be treated as a time interval indicated by the line 71 in FIG. 4B and the recognition of the presence of any type of trailing vehicle within such interval as indicated by the dashed pulse 72 will suffice to satisfy the conditions of the tailgate computer 60. The end of the interval 71 also signifies a cutoff condition whereupon the receipt of a later pulse 74 as indicated in dashed lines is ignored for satisfying the tailgate function. Of course, the pulse 74 of the trailing vehicle is treated in an identical manner as the first received pulse, and the system contains sufficient capacity to create a new time interval and provide the desired visual presentations for such succeeding vehicles.

As indicated also in FIG. 4B, the tailgate computer 60 operates on a time sharing basis in servicing a plurality of gantries and it is to be noted that the information can be received from the specific gantry and relayed back as indicated by the dashed vertical lines 75, in sufficient time to prepare the components of the system to perform the tailgate function prior to receipt of the pulses from the trailing vehicles.

Essentially then it is only necessary to calculate a definite time interval for a received set of input data, synchronize such time interval with the receipt of the first pulse and sense whether a second pulse of information is received within that time interval in order to actuate the tailgate display.

In the preferred embodiment of the tailgate computer depicted in FIG. 3, a data link receiver 76 and transmitter 78 is provided for communications with a plurality of gantry locations, discrimination between signals being effected by frequency separation, coded signals or the like. For purposes of economy, only a single computer 79 is utilized for a plurality of gantries and conveniently, other register and storage circuitry 80 can be located therewith for ready access to the computer. The block diagram showing in FIG. 3 includes sufficient capacity to handle the information from four lanes of traffic and it will be understood that such circuitry may be expanded to accommodate any number of lanes of traffic having consideration for the capacity of the computer and the ability to rapidly treat the information.

A sequencer unit 81 is shown associated with the computer 79 for cyclically interrogating the storage registers 80 for each individual lane of traffic and for storing the computed interval for control of the display function. The registers 80 include information registers 82 connected to the receiver 76 of the data link to randomly receive and store the class identification and velocity information as received from each lane of traffic and simultaneously to record the time of receipt of such information, such latter data being provided by a clock source 84 connected to all of the registers 80 and to the computer 79. Upon interrogation of the data in the information register 82 and application of same to the computer 79 for calculation purposes, the information register 82 will be reset to a condition in preparation for receipt of additional information from the lane of traffic. Such information register 82 thus may comprise a conventional binary register of the integrated circuit type, for example, having sufficient capacity to contain the desired information.

The computer 79 acts upon such information along with information of the existing local conditions, provided at 85, to calculate the proper time interval, synchronize the time interval with the time of receipt of the information by means of the clock 84, and set the remaining interval into interval registers 86 for control of the tailgate function. In this embodiment of the invention, the interval registers 86 thus may comprise a binary counter which are presettable to any desired count within their capacity, which count is continuously diminished by input pulses received from the clock source 84.

Logic elements 88 comprising AND gates are connected to sense the presence of a count in the interval registers 86 and receive at a second input pulse information from the receiver 76 so that when a succeeding pulse is received within the desired interval, an output pulse on one of the lines 89 is developed for application to the transmitter 78. The signal is then transmitted to the appropriate gantry receiver 59 in order to activate the tailgate display 48 for that lane of traffic. When the interval register 86 is counted down to zero count, indicating the completion of the interval, the AND-gate 88 will be in an off condition to prevent the transmission of succeeding pulses. It will be evident then in this embodiment of the invention that input information is entered randomly into the information registers 82 as received, is interrogated cyclically by the sequencer 81, operated upon and synchronized by the computer 79 and stored in the interval register 86 for receipt of a further pulse of random information.

The environmental factor upon the calculation if indicated as the entry into the computer 79 of information received from a source 85 labeled local conditions. This source 85 may provide data from manually adjustable devices relating to the type of roadway upon which the traffic is being monitored; continuously variable information from humidity, fog, rain and ice detectors; as well as data from a clock or photoelectric light sensor for introducing the light factor into the computation.

While the exact programming of the computer 79 is not described in detail, it will be apparent to those skilled in the art that such factors can be readily accommodated to have the effect of either lengthening or shortening the time or distance interval of unsafe conditions. The weight given to each of such individual factors may be determined from engineering and/or statistical studies and may be varied to some extend to suit known results from an operating system. However, it will be generally appreciated that the computer 79 may be programmed along the following outline: Faster speeds call for a greater unsafe distance interval which is converted to an interval of time at any particular speed. Also, a relatively longer time interval indicating a larger unsafe following distance is desired when the class of vehicle is large, the road surface is of less than the best grade, the weather conditions are poor, and the available light is dim. Shorter intervals are indicated when the converse conditions prevail.

Referring now to FIGS. 5 and 6, two alternative embodiments for the tailgate computer 60 are depicted generally being connected into the system shown in FIG. 2 as the dashed block 90 designated alternate tailgate by the dashed line interconnections. These alternative embodiments have the advantage of locating much of the logic circuitry at the particular gantry thereby reducing the complexity of a remotely located computer and the embodiment depicted in FIG. 6 obviates completely the necessity for a remote computer as at 60 providing the complete computation at the gantry location. Further, such alternative embodiments alleviate to a great extent the problem of synchronizing the receipt of pulse information with the calculation of the desired interval of unsafe following distance.

Referring now to FIG. 5 there is shown a binary counter 92 having sufficient capacity to count throughout the longest time interval which will be calculated, such counter 92 receiving an energizing pulse from the class identification circuit 55 to initiate an automatic counting mode. A binary register 94 of similar capacity is depicted, such register 94 being presettable to a specific number as determined from the remote computer 60 and adapted to retain such number until reset. A comparator circuit 95 monitors the outputs of the counter 92 and register 94 on a continuing basis for control of an AND-gate 96, such arrangement being effective to hold the gate 96 in the open condition so long as the count in the counter 92 is below that indicated in the register 94. When a succeeding pulse is received from the class identification circuit 55 while the gate 96 is in the open condition, such pulse will be transmitted to the tailgate portion 48 of the display board 47 for illumination of the display for a predetermined interval as explained with reference to the preferred embodiment of the invention.

In the mode of operation of this system, the count in the counter 92 is always synchronized with the receipt of the first pulse and the only requirement is that the information entered into the register 94 be provided prior to the completion of the interval, within a sufficient time so as to allow for receipt of a trailing pulse. The remote computer 60 again can operate on a time shared basis, sequentially interrogating the data available at each gantry, and with the present day third generation type of computers, operating times are sufficiently fast to allow such calculations to be performed in relatively small time interval in relation to the unsafe following distance time interval calculation desired.

Yet another form of apparatus for providing the tailgate interval is depicted in the FIG. 6 embodiment of the invention wherein a one-shot timing component 97 is shown adapted to be triggered from a pulse received from the class identification circuit on line 98. The one-shot 97 may be any form of monostable device having the characteristic of changing state for a predetermined time interval upon energization. An AND-gate 99 is connected to sense the change of state of the one-shot 97 being conditioned for receipt of a succeeding pulse from line 98, to transmit the pulse to the display board 48. Typically, the one-shot 97 operates on the principle of capacitor discharge, the rate of discharge determining the desired time interval and such rate is modified by a variable impedance element 100 connected in the capacitor circuit. The variable impedance element 100 may comprise a form of ladder impedance network receiving as inputs the class identification signal, the speed signal, and the data representing environmental conditions, the latter now comprising the appropriate sensors located in situ at the gantry itself and exactly coordinated with the environmental conditions at that particular location. Again, in this embodiment of the invention, automatic synchronization between the unsafe following interval and the receipt of the pulse from the class identification circuit **55** automatically occurs so that no clock or timing source is required. It is still desired, however, to relay the information to the central computer **61** associated with the highway system and the display of such retransmitted information is fully compatible in this embodiment of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A traffic control system for developing information of existing traffic conditions comprising means responsive to the movement of vehicles along a roadway for producing a series of signals indicative of such traffic, one of said signals being representative of the velocity of a vehicle, means responsive to said one signal for generating a time interval having a duration related to said one signal, means for sensing the condition of the production of a second one of said signals within such time interval, and means responsive to said sensing means for providing an indication of such condition.

2. The control system as set forth in claim **1** wherein said indication means comprises a device for presenting information in visual form, said device being disposed near the roadway being monitored for viewing from the vehicles.

3. The control system as set forth in claim **2** wherein said time interval generating means comprises a computer programmed to develop an output as a function of the velocity of the vehicle, said output being operative to condition said sensing means for receipt of said second signal.

4. The control system as set forth in claim **3** further including means responsive to said signal producing means for discriminating among signals representative of the type of vehicles, said discriminating means being operative to modify the output of said computer.

5. The control system as set forth in claim **3** further including means for registering environmental conditions in the area of the traffic, said registering means being operative to modify the output of the computer.

6. A system for monitoring the movement of vehicles along a roadway comprising means for directing a train of signals at a predetermined location of the highway which signals are intercepted and reflected by moving vehicles, means for receiving the reflected signals from the vehicles, doppler frequency sensing means coupled to said receiving means for providing an indication of the velocity of said vehicles, discriminating means coupled to said sensing means for categorizing the types of reflected signals into various classes of vehicles, means responsive to said doppler means and said discriminating means for determining a time interval having a duration related to the velocity and class of vehicles, means operative within such time interval for sensing the receipt of a reflected signal at said receiving means, and indicator means responsive to said sensing means for registering such condition.

7. The system as set forth in claim **6** wherein said indicator means comprises a display proximate to the roadway in the line of sight of operators of the vehicles.

8. The system as set forth in claim **7** wherein said discriminating means comprises a first detector coupled to said receiving means for monitoring the amplitude of the reflected signals and for providing output signals representative thereof.

9. The system as set forth in claim **8** wherein said discriminating means further comprises a second detector coupled to said receiving means for monitoring the interval of the reflected signals, said second detector being responsive to said doppler means for providing output signals representative of classes of vehicles, and means for combining the outputs of said first and second detector means to provide a further classification of the vehicles.

10. The system as set forth in claim **9** further including means for monitoring environmental conditions in the area of the roadway and for providing a signals representative thereof, said time interval determining means being further dependent upon said monitoring means.

11. The system as set forth in claim **10** wherein said time interval determining means comprises a computer programmed to combine the indications of velocity, vehicle class and environmental conditions to provide an indication of a time interval related thereto, said sensing means being operative in response to said computer indication.

12. The system as set forth in claim **11** further including a second computer operatively connected to receive the indications of velocity and vehicle class from said doppler means and said discriminating means respectively, said second computer being programmed to accumulate such indications and compute density of vehicles and flow rates for the roadway.

13. A system for monitoring vehicular traffic comprising a radar system for producing sequential echo signals from the moving vehicles, means responsive to the echo signals for indicating the velocity of the vehicles, means responsive to the echo signals for indicating the class of vehicles, means operatively connected with said class means and said velocity means for detecting sequential indications within a time interval determined by such indications, and means operatively connected with said detecting means for providing a visual display representing such sequential indications.

14. The system as set forth in claim **13** wherein said detecting means comprises a variable time delay circuit, said circuit being triggered into operation by receipt of a first indication, a gate responsive to operation of said circuit and a second indication for providing a signal to said display means, and means for varying the delay of said circuit as a function of the indications.

15. The system as set forth in claim **14** wherein said delay circuit is a one-shot circuit and said varying means comprises a variable impedance element operatively connected to control the discharge time of said one-shot circuit.

16. The system as set forth in claim **14** wherein said delay circuit is a digital counter and said varying means comprises a computer operatively connected to control the maximum count of said counter, said computer being operative in the interval between sequential indications.

17. The system as set fourth in claim **13** wherein said detecting means comprises an information register for storing the indications of said class means and said velocity means, a sequence circuit for interrogating said register, a computer connected to said sequence circuit for developing an interval instruction as a function of the information in said register, a circuit responsive to said interval instruction and a sequential indication to provide an output signal to said display means, and means for synchronizing said computer with the receipt of the sequential indications.

18. The system as set forth in claim **17** wherein said synchronizing means comprises a clock source operatively connected with said information register and said computer and operative to determine the magnitude of the interval instruction.

19. A system for classification of vehicles comprising means for developing a pulse group of echo signals from a moving vehicle, said signals having amplitude related to frontal reflective surface of the vehicle, doppler frequency related to velocity and duration related to length and velocity, means for sensing amplitude of the signals and for providing output signals representative of the frontal reflective surface of the vehicles, doppler frequency detector means for determining the velocity of the vehicles, means for sensing the duration of the signals to provide indications proportional thereto, means for combining the indications of said duration sensing means and said doppler detector means to provide output signals representative of the length of the vehicles, and means for combining the output signals to provide a combined classification of the frontal surface and length of the vehicles.

20. The system as set forth in claim **19** wherein said first named means comprises a radar unit located above a lane of traffic to be monitored and directed at a small angle below a horizontal line toward oncoming traffic to provide both frontal and longitudinal reflection from the vehicles.

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