July 6, 1965 M. ROSS PALMER 3,193,798

TRAFFIC DENSITY METER

Filed May 29, 1959

FIG. 1

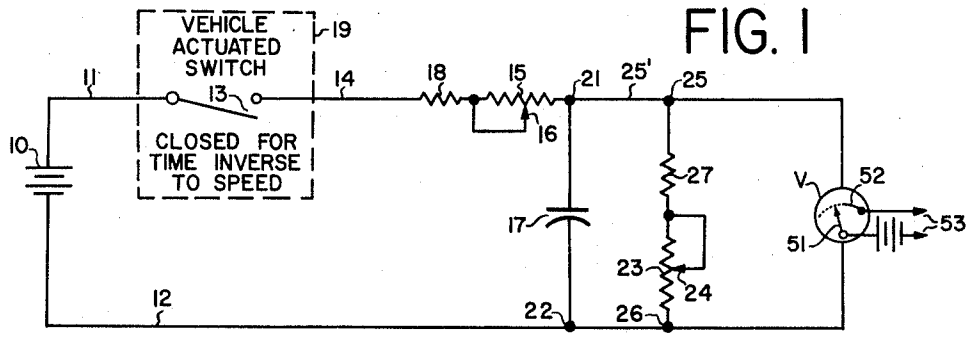


FIG. 2

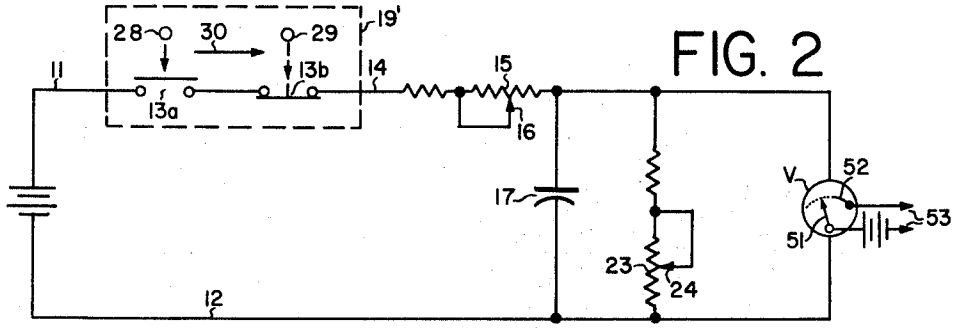
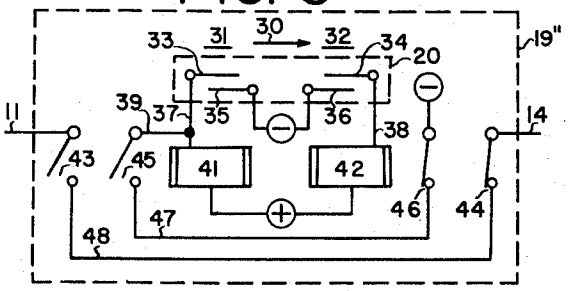


FIG. 3



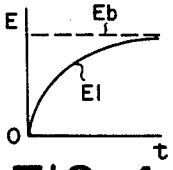


FIG. 4

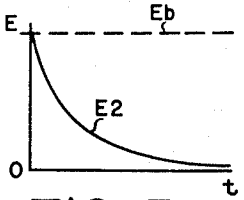
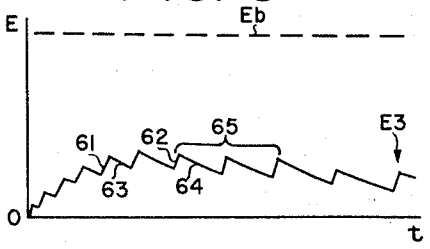


FIG. 5

FIG. 6



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TRAFFIC DENSITY METER

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15 Claims. (Cl. 340—31)

The present invention relates to a traffic density meter for directly measuring the number of vehicles per unit length of roadway, which may be indicated as vehicles per mile for example.

The invention more particularly relates to electrical apparatus for directly determining the traffic density of traffic moving at substantial speed as such traffic passes or has passed a desired checking point on or adjacent a roadway.

The invention further relates to an improved simplified form of such apparatus providing an indication of traffic density of the passing traffic as a continuously running average, and for a substantial range of traffic volume and of speed.

The apparatus uses relatively few and readily available components providing a relatively compact and low cost assembly adapted for portable use for example as well as permanent installation.

The term "traffic density" as used herein relates to the number of vehicles per unit distance along the road, as in a single traffic lane or one of several parallel traffic lanes in the roadway, and the term should be distinguished from its older use to a large degree as having the same meaning as traffic volume, the latter being the number of vehicles passing a point per unit of time.

The present use herein of the term "traffic density" is in accordance with the definition given on page 477 of the Traffic Engineering Handbook, 2nd edition, published 1950 by the Institute of Traffic Engineers and the Association of Casualty and Surety Underwriters.

In accordance with the invention the traffic density of a moving stream of traffic is determined by progressively accumulating a charge on a capacitor by pulses whose number corresponds to the number of vehicles passing and whose length is inversely proportional to the speed of the vehicles, while opposing such accumulation by the progressive slow discharge at a desired time rate, so that the accumulated charge is substantially proportional to the product of the number of vehicles per unit of time and the inverse of their speeds and thus representative of the traffic density or number of vehicles per unit distance for the group of vehicles which have passed the detection point within the period of the discharging time base for example.

The charge or voltage on the capacitor represents a substantially true density when the rate of accumulation of increments of charge equals the rate of discharge, and approaches such true density exponentially with a time lag in accordance with the time base of the discharge whenever the density is increasing or decreasing. The rate of accumulation of increments of charge will be equal to the rate of discharge whenever the density has remained substantially the same for a time period approximating or exceeding the time base for discharge or whenever the current instantaneous density is equal to the density as averaged over the time base, for example.

Thus the charge or voltage on the capacitor represents a running average of the traffic density of the passing traffic, and a meter having a very high input impedance, such as a vacuum tube voltmeter, can be connected across the capacitor and calibrated directly in traffic density or vehicles per unit distance, such as vehicles per mile for example.

The density can be expressed on a shorter or longer distance, as a rate as desired, even though the time base remains the same, but the time base may also be varied by adjusting the amount of discharge resistance. The amount of charge added by each vehicle actuation at a given speed may also be varied over a substantial range by adjusting the resistance in the charging circuit. Both adjustments may be made together by increasing the resistances to increase the time base while decreasing the charge per actuation at a given speed or by decreasing the resistances to decrease the time base while increasing the charge per actuation at a given speed for example so that the meter indication will remain the same for the same traffic density.

It is therefore a general object of the invention to provide a direct reading traffic density meter of compact and low cost construction.

It is also an object of the invention to provide an electrical apparatus for measuring the traffic density of a moving stream of traffic in a traffic lane by charging a capacitor incrementally by amounts substantially proportional directly to the number and inversely to the speed of the vehicles in the traffic stream passing a detection point and discharging the capacitor progressively at a predetermined time rate so that the charge on the capacitor is representative of a running average of the traffic density, which may be applied to a meter calibrated directly in vehicles per unit distance.

Further objects may appear from the claims appended to the following description with reference to the accompanying drawings in which:

FIG. 1 is a schematic circuit diagram of a traffic density meter according to the invention, in one simplified form.

FIG. 2 is a schematic circuit diagram of an alternate form of a traffic density meter which is the subject of the invention.

FIG. 3 shows a further alternate form of a portion of the traffic density meter shown in FIGS. 1 and 2.

FIG. 4 shows the general form of an exponential charging curve for a capacitor through a resistance.

FIG. 5 shows the general form of an exponential discharging curve for a capacitor through a resistance.

FIG. 6 shows in general form a curve illustrating some of the combined effects of charging and discharging a capacitor in accordance with the circuitry of FIGS. 1, 2 and 3.

Referring now to FIG. 1, the battery 10 illustrates a source of direct current supply to provide a positive voltage on line 11 with respect to a negative return on line 12, for example. A battery is shown for simplicity of illustration but it will be understood that other forms of D.C. supply may be substituted such as provided by rectification and smoothing of alternating current, as well known in the art.

The positive voltage on line 11 is connected to the left side of switch 13 which is shown in the open position, which is its normally inactive or non-actuated condition.

As indicated, switch 13 is designed to be closed by vehicle actuation for a brief time period substantially inversely proportional to the speed of the actuating vehicle.

When switch 13 is closed the positive voltage from line 11 is extended to line 14 and via the fixed resistance 18 and adjustable resistance 15, which may be in the form of a potentiometer, to junction 21 and thence to the upper side of capacitor 17. The lower side of capacitor 17 is connected to junction 22 on line 12, the negative or return side of the D.C. supply 10. The potentiometer 15 is shown in the usual manner with adjustable sliding contact arm 16.

A further adjustable resistance 23 in the form of a potentiometer having arm 24 and an associated fixed resistance 27 are connected in series across capacitor 17,

the connection to the upper side of the capacitor being via junction 25 and line 25' and junction 21, and the connection to the lower side of a capacitor being via junction 26 on the extension of line 12 and via junction 22 on line 12, connected to the capacitor.

The fixed resistors 18 and 27 are relatively small compared with their associated potentiometer resistances and serve to set a minimum limit to the adjustment. If it is desired to adjust the resistance value substantially to zero however, as in testing or resetting the apparatus in a particular application, the fixed resistor can be replaced by a direct connection or shunted by a switch.

The relative values of the resistance to be employed for the potentiometers 15–16 and 23–24 depend upon the length of closure time of the switch 13 in response to passing vehicles and the length of time over which it is desired to determine the average density of the vehicular traffic, but normally the switch 13 will be closed for quite brief periods of the order of a small fraction of a second to one second or so depending upon the type of switch employed and the speed of the vehicle actuating it, whereas the discharge circuit may have a time constant of the order of one fourth of a minute to two minutes for example, although it is not intended that these shall be limiting values.

The closure of the switch 13 in response to vehicle actuation may be by each vehicle wheel or by the whole vehicle depending upon the form of vehicle actuation employed. There are various known forms of vehicle actuated switches including hermetically sealed pressure operated contact switches, air tube and diagram switches operated by the pressure wave as a vehicle wheel passes over the road tube, and the widely used radar vehicle detector for example.

It will be understood that the switch 13 may represent the contact of a relay operated in turn by a vehicle actuated switch as described later in connection with FIG. 3 or otherwise, and this is usually preferable, although where the connecting line 14 is short and can be provided with a high quality cable with very low electrical leakage to ground which may be assumed to be the other line 12, and where the vehicle actuated switch 13 can also be provided of high quality sealed construction with very low leakage, the vehicle actuated switch may be of the type directly actuated by pressure of the vehicle wheel.

In any event the switch 13 will be closed for a very brief pulse with the passage of each vehicle wheel or axle or each vehicle depending on the type of vehicle actuated switch, and for the present it will be assumed that it will be closed for each vehicle. Upon each such brief closure the capacitor 17 will be charged a small amount or increment along its characteristic exponential charging curve illustrated in general form in FIG. 4 as discussed below. The amount of such small charge added to capacitor 17 will be governed by the control resistances 15 and 18 and will also be proportional to the time of closure of the switch 13 for the quite short closure time periods that will normally prevail in moving traffic, the amount of charge added being a function of the voltage difference between the D.C. voltage between lines 11 and 12 and the voltage on the capacitor due to any charge already thereon as well as being a function of the control resistance and time. For any given size of capacitor the voltage across the capacitor is proportional to the charge on the capacitor, and in general in charging a capacitor its voltage follows a characteristic curve depending on the applied voltage, the amount of resistance, the amount of capacitance, and time. These factors are related by a formula discussed below in connection with FIG. 4.

When the switch 13 opens between vehicle actuations the capacitor 17 will have its total charge reduced progressively by the discharge circuit via the control resistances 23 and 27 according to a formula discussed below in connection with FIG. 5. Since the amount of each increment of charge is proportional substantially to the length of closure time of switch 13 when operating on the initial or lower part of the charging curve, these increments of charge tend to accumulate against the discharge, which discharge is at the desired adjusted time rate, and the increments of charge added are inversely proportional to the speed and thus the total charge on the capacitor 17 at any time approximates the product of the number of increments of charge times the time length of such increments less the progressive loss of charge provided by time along the discharge curve.

Thus each vehicle pulse and increment of charge introduces the density factor and the summation of such charges against the progressive discharge rate per unit time causes the voltage across the capacitor 17 to assume a value substantially proportional to traffic density in vehicles per unit distance, over the normal range of values over which the density meter is to operate. As pointed out above this is effectively a density value as averaged over a time period and corresponds to the actual density value when the traffic density has remained substantially the same over the averaging time period based on the discharge rate.

A very high impedance voltmeter V, which may be of the familiar vacuum tube voltmeter type, for example, is connected across capacitor 17 and the parallel discharge resistance between junctions 25 and 26 to indicate the voltage on the capacitor, and this meter may be calibrated directly in traffic density in terms of vehicles per unit distance so that the traffic density of a moving stream of traffic may be indicated directly as a continuously running average.

This meter V may be of the indicating or recording type and may also be of the meter relay type or otherwise provide an output above a given value of density. Thus the meter pointer 51 may cooperate with a contact segment 52 on the upper part of its scale to close an output circuit 53 for operation of an external device above a preset density for example, if desired.

This meter V may have its response damped in a well known manner if desired to smooth out somewhat the output indication as the voltage on capacitor 17 rises above and falls below the average value with the charging and discharging action.

It will be understood that for extremely low traffic speeds where traffic is barely moving or if for any reason the switch 13 should be kept continuously closed or blocked from closing, the circuit would not be able to respond fully and a proper density reading could not be determined for these extreme conditions. However, for the ordinary range of normal operating conditions the traffic density can be measured over a substantial range of traffic speeds and traffic volumes.

FIG. 2 illustrates a circuit which is similar to that of FIG. 1 except for a different form of vehicle actuated switch means in the broken line box 19' of FIG. 2 corresponding to the broken line box 19 of FIG. 1. In FIG. 2 the circles 28 and 29 in the box 19' indicate schematically in cross section form two successive road tubes which are designed to be actuated in sequence by a vehicle wheel proceeding in the direction of the large arrow 30 for example. The first road tube 28 is designed to close switch 13*a* on such vehicle wheel actuation and the second road tube 29 is designed to open switch 13*b* upon such vehicle wheel actuation.

In the simplest case it can be assumed that the road tubes are spaced closely enough together so that the vehicle wheel will actuate the road tubes 28 and 29 in an overlapping sequence so that switch 13*a* will remain closed until after switch 13*b* has initially opened, but as the vehicle proceeds further the switch 13*a* will reopen before the switch 13*b* recloses as the vehicle wheel continues in the direction of the arrow 30.

In the assumed case of overlapping actuation it will be clear that the initial closure of switch 13*a* closes the charging circuit previously traced for capacitor 17 via poten-

tiometer 15–16, and the charging circuit is reopened again upon opening of switch 13*b* by actuation of road tube 29. Thus the closure of the charging circuit will be for a time inversely proportional to the speed of the vehicle actuating the road tubes.

The alternate form of circuitry of the actuating switch arrangement in box 19' in FIG. 2 is the only circuit change, the remainder of the circuit diagram being the same as FIG. 1, although readjustment of the values of the control resistances may be required based on the length of closure time of the circuit through the switches 13*a* and 13*b* in comparison with the closure time of the switch 13 in FIG. 1.

The simplified form of the invention illustrated in FIG. 1 assumes that the switch 13 will be closed for times substantially inversely proportional to the speed of the actuating vehicle. In some instances over a reasonable range of substantial speeds and for certain types of vehicles such as all passenger cars on a parkway for example where commercial traffic or trucking is prohibited, the switch 13 may represent the simple form of single contact pressure detector as in U.S. Patent 1,950,490 issued March 13, 1934 to C. D. Geer and E. D. Stirlen for example, or may represent a contact of a relay directly operated by such a treadle switch, or that of U.S. Patent 1,928,472 issued September 26, 1933 to H. A. Wilcox, embedded in the roadway, for use in the present circuitry for obtaining an approximation of density.

However, for applications of widely mixed traffic the length of the tire pattern on the road for large and small vehicles will vary sufficiently so that it will be desirable to use a circuit of the general type illustrated in FIG. 2 or of the type illustrated in FIG. 3 in which an initial switch closes the circuit and a subsequent switch opens the circuit in the desired direction of traffic, which thereupon makes the circuitry independent of the length of tire pattern, since the leading edge of the tire pattern of the wheel will actuate the two switches in succession and the length of time between such actuations will be substantially inversely proportional to the speed of the actuating vehicle.

A further form of the actuating means is shown in FIG. 3, illustrating how the switches in the circuit between lines 11 and 14 of the circuit diagrams of FIG. 1 or FIG. 2 can be provided by contacts of relays which in turn are operated by treadle switches or road tube switches or other forms of vehicle detectors. The circuitry within the box 19'' of FIG. 3 can be substituted for the circuitry in the box 19' in FIG. 2 or the box 19 in FIG. 1, while the remainder of the circuitry remains the same, subject to adjustment of the resistances as desired to allow for the closure time of the substituted switch means. Thus for example, if the circuit closure time for FIG. 3 is ten times the closure time for FIG. 1 for a given speed, then the resistance of potentiometer 15–16 would be adjusted or its value changed to ten times its previous value so that the amount of increment of charge added by actuation at such speed would remain the same, for example, for the same adjustment of potentiometer 23–24.

In FIG. 3 the line 11 corresponds with the similarly numbered line in FIGS. 1 and 2 and the line 14 at the right corresponds with the similarly numbered line in FIGS. 1 and 2. A pair of road switches 31 and 32 are illustrated schematically within a broken line block 20, which may represent a two-contact treadle switch assembly as illustrated in U.S. Patent 2,077,924 issued to C. D. Geer and J. L. Biach April 20, 1937 for example, the lower contacts 35 and 36 being either separate or a common contact since they are both connected together to a negative power terminal indicated as minus in a circle, which may be a grounded A.C. or D.C. terminal. The upper contact 33 cooperates with the lower contact 35 in switch 31 and the upper contact 34 cooperates with the lower contact 36 in switch 32.

The switches 31 and 32 are designed to be operated in sequence in the direction of the arrow 30. In the present instance, although the switches are shown as within a broken line block 20, they may be either close enough to be actuated in overlapping sequence as described above in connection with FIG. 2 or they may be somewhat further apart and independent switches. Thus they may be spaced of the order of six inches to one foot apart in the direction of traffic, and these switches 31 and 32 may illustrate either direct operated pressure contact switches or may illustrate road tube operated switches but in each case in FIG. 3 have normally open contacts which are closed momentarily by passage of a vehicle wheel.

The switch 31 controls relay 41 and the switch 32 controls relay 42. The upper side of the coil of relay 41 is connected via lead 37 to the upper contact 33 of switch 31 which when closed completes a connection via the lower contact 35 to the negative terminal shown as minus in a circle. The other side of the coil 41 is connected to the positive power terminal shown as plus in a circle, as is also the lower side of the coil 42. The upper side of the coil 42 is connected via lead 38 and contact 34, which when switch 32 is closed is connected via its lower contact 36 to the negative terminal previously described.

Thus when switch 31 closes it energizes relay 41 via the circuit described and closes its normally open contacts 43 and 45. The closure of contact 45 provides a holding or locking circuit for relay 41 from the upper side of its coil at line 37 and via line 39, contact 45, line 47 and normally closed contact 46 of relay 42 to the negative power terminal which is shown repeated for convenience. Thus when relay 41 is initially operated it locks up over its own contacts 45 until the normally closed contact 46 of relay 42 is opened.

Relay 42 is energized by the closure of switch 32 and opens its normally closed contacts 46 and 44.

Thus when relay 41 is initially operated by closure of switch 31, its contact 43 is closed and via line 48 and the normally closed contact 44 of relay 42 this completes a circuit between line 11 and line 14 for closure of the charging circuit as in FIG. 1 or in FIG. 2. This circuit remains closed until the subsequent actuation of switch 32 whose closure operates relay 42 to open its normally closed contact 44 and thus interrupt the circuit between lines 11 and 14. At the same time the operation of relay 42 at its contact 46 opens the lock-in circuit of relay 41 and releases the latter so that both relays return to normal as the vehicle proceeds beyond the switches in the direction of the arrow.

Thus in FIG. 3 another form of closure of the charging circuit is illustrated employing contacts controlled by relays which are operated in sequence by the vehicle actuated switches to provide a closure time for the charging circuit inversely proportional to the speed of the actuating vehicle, and in the form of circuit illustrated in FIG. 3 the switches 31 and 32 can be placed further apart and do not require an overlapping sequence of actuation.

It will be understood that the locking circuit involving contacts 45 and 46 may be omitted if the switches 31 and 32 are close enough for overlapping actuation. Relay 42 may be a quick operating and slow release relay to provide some overlap in the direction opposite to the arrow to prevent leaving relay 41 locked up at substantial speeds of vehicles passing in the wrong direction, but the present apparatus will ordinarily be used in a single lane having traffic only in the desired direction.

FIG. 4 shows the general form of exponential curve E1 for the charging of a capacitor through a resistance, indicating charge or voltage E on the vertical scale in relation to time *t* on the horizontal scale for an applied voltage E*b*. Thus the curve E1 shows the voltage E on the capacitor in charging from zero according to the known formula $E=Eb(1-e^{-t/RC})$ where E*b* is the battery voltage, *e* is the exponential base constant 2.7183, R is the charging resistance in ohms and C is the capacitance of the capacitor in farads, as time *t* varies from

zero, the curve E1 approaching the applied voltage E*b* as a limit.

Thus the curve E1 in FIG. 4 may illustrate the manner in which capacitor 17 would charge via resistances 18 and 15 for a voltage E*b* of battery 10, assuming starting from a fully discharged condition and then the discharge circuit is disconnected and the switch 13 is held continuously closed over the time *t*. If the discharge resistance is very much larger than the charging resistance the curve E1 would approximate the charging curve of capacitor 17 with the discharge circuit closed as well as switch 13 closed, except that the upper part of the curve would approach a limit somewhat below E*b*.

In any event the curve rises to about 63% of E*b* where *t* equals the product RC, and rises to about 86.5% of E*b* when $t=2RC$ and to about 95% of E*b* when $t=3RC$, and it will be obvious that the time for reaching a given voltage or percentage of full voltage E*b* will vary directly with the resistance for a constant capacitance or directly with the capacitance if the resistance is constant.

FIG. 5 shows the general form of exponential discharge curve E2 on a similar basis, the voltage E on the capacitor falling from the initial value of E*b* at a decreasing rate to zero as a limit. This curve follows the formula $E=Ebe^{-t/RC}$ so that the voltage E on the capacitor reaches about 37% of E*b* at $t=RC$ and 13.5% at $t=2RC$ and 5% at $t=3RC$. The curve E2 illustrates the discharge of capacitor 17 as C through resistance 23 and 27 as R with switch 13 open, as between vehicle actuations of the switch.

FIG. 6 shows the combined effects of charging by pulses following approximately the curve E1 of FIG. 4 over its lower part and discharging between pulses following the curve E2 of FIG. 5, for a series of actuations or brief closures of switch 13 for example. The sawtooth effect of the curve E3 is enlarged for convenience of illustration and the curve E3 shows the voltage or charge accumulated on capacitor 17 as it rises at 61 and 62 for example during the brief charging pulses with switch 13 closed and as it falls at 63 and 64 for example with switch 13 open between charging pulses. The rising parts follow approximately the curve E1 at corresponding voltage levels and the falling parts follow the curve E2 at corresponding voltage levels.

The rise 61 illustrates a longer pulse from a slower vehicle and the rise 62 a shorter pulse from a faster vehicle, and the different lengths of the falling parts 63 and 64 illustrate different spacings between vehicles or vehicle actuations, 64 illustrating a greater spacing representing a somewhat lower volume of traffic.

The curve E3 in FIG. 6 is shown starting from zero as illustrating starting from a reset or completely discharged condition. This left end of curve E3 serves to illustrate vehicles passing sufficiently closely and at moderate speed such that the accumulation of charge by the pulses is greater than the discharge between pulses and the average density is rising. The right end of the curve E3 shows some decline in density as averaged by the discharge between increments being greater than the charge during the charging increments.

The relatively level part 65 of curve E3 illustrates a substantially stable condition when the rate of accumulation of charge is balanced by the rate of discharge and the voltage on the capacitor 17 represents steady true density. It will be understood that a balance of charging and discharging may be reached at various levels at smaller percentages of E*b* at lower density or at higher percentages of E*b* at higher density, but the ratio of the charge resistance to the discharge resistance may be varied to determine the operating range in relation to the voltage E*b* of the battery and to allow for different closure times for the vehicle actuated switches of different types and for the spacing in case of paired or separated switches as in FIG. 2 or FIG. 3.

Similarly the ratio of discharge resistance to charge resistance will be adjusted to allow for one actuation per vehicle, as originally assumed for convenience of explanation, or for more actuations per vehicle as by an actuation by each axle of the vehicle, which is the usual case with vehicle actuated treadle switches or road tubes in the roadway. For two axle vehicles and one actuation per axle, the resulting two actuations per vehicle would cause the charging rate per vehicle to be approximately doubled as compared to one actuation per vehicle if the charging resistance remained the same, and therefore the ratio of the discharge resistance to the charge resistance should be halved either to return to the same charging rate per vehicle or to provide a faster discharge to match the faster charge so that the voltage level and corresponding density indication would remain the same in vehicles per unit distance.

The ratio of resistances is preferably adjusted for maximum accuracy to operate on the middle to lower part of the charge and discharge curves, that is at a low percentage of the charging voltage for the maximum density anticipated in the normal working range, but the apparatus can be adjusted for a more rapid or sensitive shorter period averaging with some reduction in accuracy by using a smaller resistance and working up into the upper part of the charge and discharge curves up to or approaching the 87% point for example, if desired.

As one example of assumed values, but without intending to be limited thereto, if a six inch spacing is employed for the vehicle actuated switches in FIG. 2 or in the FIG. 3 modification of FIG. 2, and assuming two actuations per vehicle (i.e. one actuation per axle for two-axle vehicles), a charging time constant $RC=t=0.10$ seconds may be employed for a discharge time constant $RC=t=20$ seconds. Such assumed charging time constant is approximately the time required to charge capacitor 17 continuously from zero to 63% of the battery voltage or from any intermediate initial voltage or total charge to 63% of the difference between said initial voltage and the full battery voltage. Such assumed discharge time constant is approximately the time for continuous discharge of the capacitor 17 from any initial or intermediate voltage or total charge to 37% of such voltage, and also corresponds to a time of one minute to discharge to 5% of such voltage.

The stability of the charge on the capacitor and of the traffic density it represents may be increased and the sensitivity of response decreased by increasing the time constant.

In this connection it will be appreciated that a vehicle or vehicle wheel will travel a distance of six inches in about one thirtieth of a second (.033 sec.) at 10 miles per hour or in about one hundreth of a second at 33 miles per hour for example, and that these times approximate the length of time the charging circuit would be closed by a vehicle wheel for such spacing for the circuit of FIG. 2 at the respective speeds. The times for other speeds for the same spacing would be inversely proportional to the speed whether between or outside the values in the above example.

Examples of road tube operated switches may be found in U.S. Patent 2,362,874 issued November 14, 1944 to G. G. Wiley and in British patent 473,982 accepted October 25, 1937.

Certain variations in the form of apparatus or method in accordance with the invention have been described, and it will be obvious to those skilled in the art that numerous other changes in construction or rearrangement of parts might be resorted to without departing from the spirit of the invention as defined by the claims.

I claim:

1. A traffic density meter for vehicular traffic moving along a traffic path over a substantial range of speeds including switch means for actuation by a vehicle moving along a traffic path to be so actuated for a brief time period substantially inversely proportional to the speed

of the actuating vehicle, a capacitor, a constant voltage direct current source, and means for connecting said switch means and capacitor in a series circuit shunting said source for charging said capacitor in increments whose number is proportional to the number of such vehicle actuations and whose amount of charge is substantially directly proportional to said brief time period as said time period varies over a substantial range of traffic speeds, means for continuously discharging said capacitor progressively with time, and a meter connected in shunt across said capacitor to indicate the charge thereon resulting from such charging and discharging action, said meter being calibrated in vehicles per unit distance along the traffic path as traffic density.

2. A traffic density meter as in claim 1 and including output circuit means controlled by the accumulated charge on said capacitor to respond to said charge exceeding a predetermined value.

3. A traffic density meter for vehicular traffic moving along a roadway over a substantial range of speeds including switch means for actuation by a vehicle moving along a roadway to be closed by each such vehicle actuation for a brief time period substantially inversely proportional to the speed of the vehicle, a capacitor, a constant voltage direct current source, an adjustable resistor, means connecting said resistor and capacitor in a series circuit shunting said source for charging said capacitor in increments when said switch means is closed, the number of said increments being proportional to the number of such vehicle actuations and the amount of charge per increment being substantially directly proportional to such brief time period as said time period varies over a substantial range of vehicle speeds, said resistor being adjustable to provide the same increment of charge for various switches having different time periods for the same vehicle speed, a discharge circuit for progressively continuously discharging said capacitor at a desired exponential time rate, and a meter connected across said capacitor to indicate the charge thereon resulting from such charging and discharging action, said meter being calibrated in vehicles per unit distance along the roadway as traffic density.

4. An electrical apparatus for measuring the density of traffic moving at substantial speed over a substantial range of speeds, including a capacitor, first and second adjustable resistors and a constant voltage direct current source means for charging said capacitor from said direct current supply and including said capacitor, said first resistance and a switch connected in series, means for actuating said switch in response to passage of a vehicle in such moving traffic to close the charging circuit for a time period substantially inversely proportional to the speed of the vehicle, means including said second resistance connected across said capacitor for progressively continuously discharging said capacitor at a slow time rate, said first resistance being adjusted for limiting the charge of the capacitor during said time period to a relatively small part of its full charging characteristic from said direct current supply to provide an incremental such charge varying substantially directly proportional to the length of said time period over a substantial range of such speeds whereby the capacitor will be charged in increments by such vehicle actuations and will be slowly discharged between such vehicle actuations, and a high impedance meter connected across said capacitor to indicate the resulting charge on said capacitor in terms of vehicles per unit distance as traffic density.

5. An electrical apparatus for measuring the density of vehicle traffic moving along a traffic path at substantial speed over a substantial range of speeds, including a capacitor, means for charging said capacitor from a direct current supply having a constant voltage during said charging and means including a resistance and a pair of switches connected in series, means for actuating said switches successively in sequence including a period of concurrent closure of both of said switches in response to passage of a vehicle in such moving traffic in one direction to close the charging circuit for a time period inversely proportional to the speed of the vehicle, means including another resistance for progressively continuously discharging said capacitor at a slow time rate, whereby the capacitor will be charged in increments between such successive vehicle actuations and the capacitor will be slowly discharged in the absence of such vehicle actuations, and a high impedance meter connected across said capacitor to indicate the resulting charge on said capacitor in terms of traffic density.

6. Electrical apparatus as in claim 5 and in which said means for actuating said switches includes a pair of road tubes spaced along the path of the traffic for actuating the respective switches.

7. Electrical apparatus as in claim 5 and in which said switches include a normally open switch and normally closed switch and said means for actuating said switches includes road tubes closely spaced along said traffic path and associated with the switches to first close the normally open switch and then open the normally closed switch and then to restore the switches to their normal conditions in the same order as a vehicle wheel passes over the road tubes in the direction of movement of such traffic.

8. Electrical apparatus as in claim 5, in which said switches are closely spaced along said path and the switches include a first normally open switch and a second normally closed switch in order in the direction of movement of such traffic, and in which said means for actuating said switches first closes said first switch and then opens said second switch and then restores these switches to their normal condition in the same order for said one direction.

9. Electrical apparatus as in claim 5 and said means for actuating said switches including treadle switch means spaced along the path of traffic to be actuated in sequence by a vehicle wheel rolling over them in said one direction and relays individual to said treadle switches to be actuated thereby to actuate the first named switches to so close said charging circuit.

10. Electrical apparatus as in claim 5 and said means for actuating said switches including a pair of vehicle actuated switch means spaced along the path of such traffic to be actuated in sequence by a vehicle wheel rolling along said path in said one direction in such moving traffic, relays individual to the respective vehicle actuated switch means to be operated individually thereby, and such first mentioned switches comprising a normally open contact of the first of said relays to be so operated and a normally closed contact of the second of said relays to be so operated in such sequence.

11. Electrical apparatus as in claim 5 and said means for actuating said switches including a pair of vehicle actuated switch means spaced along the path of such traffic to be actuated in sequence by a vehicle wheel rolling along said path in such moving traffic in said one direction, relays individual to the respective vehicle actuated switch means to be operated individually thereby, and said first mentioned switches comprising a normally open contact of the first of said relays to be so operated and a normally closed contact of the second of said relays to be so operated in such sequence, and said first of said relays to be operated in sequence for closing said charging circuit including a self-locking means for maintaining said first relay so operated and said self-locking means being released by operation of said second of said relays to be so operated in such sequence for releasing said first relay for reopening said charging circuit.

12. An electrical apparatus for measuring the density of vehicle traffic moving at substantial speed over a substantial range of speeds, including a capacitor, a constant voltage direct current source, series circuit means for charging said capacitor from said direct current supply and including an adjustable resistance and a switch in

series, said resistor being adjusted to provide a relatively short time constant charging circuit for charging said capacitor by a small increment substantially proportional to the time period of closure of said charging circuit by said switch means for actuating said switch in response to a passing vehicle in such moving traffic to close said charging circuit for a brief time period inversely proportional to the speed of the vehicle over a substantial range of speeds, means including another adjustable resistance adjusted to provide a relatively long time constant with said capacitor. for progressively continuously discharging said capacitor at a slow time rate whereby said capacitor will be charged in increments by such vehicle actuations and will be slowly discharged between such vehicle actuations, and the resulting net average charge on said capacitor will be representative of traffic density in vehicles per unit distance as averaged over a time period.

13. An electrical apparatus as in claim 12 and including means for providing an output in response to the charge on said capacitor exceeding a predetermined value as representative of the traffic density exceeding a corresponding value.

14. In an electrical apparatus for measuring the density of vehicle traffic moving at substantial speed over a substantial range of speeds along a traffic lane, a capacitor, a circuit for charging said capacitor from a direct current supply having a constant voltage during such charging and said circuit including a resistance and switch means in series for so charging said capacitor only when said switch means closes said circuit to connect said capacitor through said resistance to said supply, vehicle actuated means for actuating said switch means in response to a passing vehicle in such moving traffic to so close said charging circuit for a brief time period inversely proportional to the speed of the actuating vehicle over a substantial range of speeds, and a circuit including another resistance connected across said capacitor for progressively continuously discharging said capactor at a relatively slow time rate whereby said capacitor will be charged in small increments by such vehicle actuations and will be slowly discharged between such vehicle actuations so that the net resulting charge on said capacitor will be substantially proportional to the density of such traffic in vehicles per unit distance along said traffic lane as averaged over a time period.

15. In an apparatus for measuring the density of moving vehicular traffic passing a sampling point over a wide range of speeds, means responsive to the passage of vehicles for generating pulses from a constant voltage source of time length inversely proportional to the speeds of individual vehicles in traffic over a substantial range of speeds and of number substantially directly proportional to the number of such vehicles in traffic passing said sampling point, means including a cumulative storage element for integrating the total time length of said pulses, and means for progressively reducing said integrated time length of said pulses on said storage element at a time rate proportional to the net total time length of pulses so integrated, to provide an output proportional to the resulting net integrated total time length of the pulses as so reduced, whereby such output will be representative of the average density of traffic in vehicles per unit of distance.

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