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CONTROL SYSTEM

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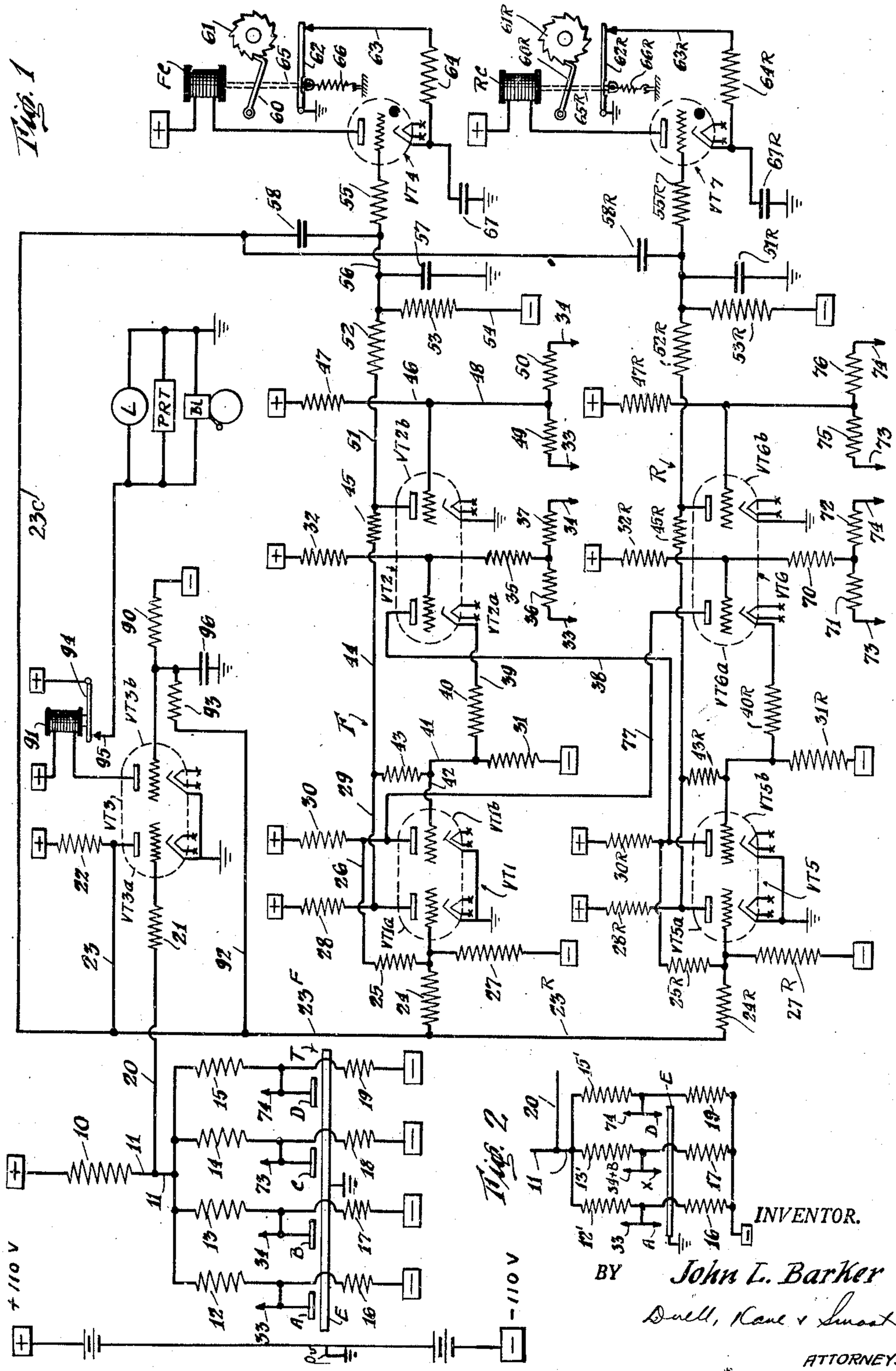

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CONTROL SYSTEM

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This invention relates to a control system for operating electrical output devices, such as counting devices or indicating devices and the like. In a particular application, the invention relates to a system for counting the passage of objects over or along a traffic artery and for insuring an accurate count in circumstances, for example, wherein a vehicle may halt and momentarily reverse while it is upon or within the zone of the actuating means for the counting device.

Control systems in accordance with the invention are especially useful in providing an accurate count of road vehicle traffic, or traffic at toll bridges, tunnels, or highways, or wherever it is desired to operate one counter for recording vehicles passing in a forward direction and another counter for vehicles passing in the reverse direction. In such installations, the operation of the system is advantageously initiated by a multi-contact treadle placed in the roadway, for actuation by a vehicle wheel rolling over the contacts in sequence. It is desired to have the counting of vehicle axles as accurate as possible and substantially proof against actuation by pedestrians or toll collectors, or by the accidental closure of one or more of the treadle contacts.

In my Patent No. 2,311,359, patented February 16, 1943, and assigned to the assignee of the present application, there is disclosed a control system employing a multiple switch treadle and a group of electro-mechanical relays actuated thereby to operate counting devices only upon actuation of the multiple switches in an overlapping sequence. The relays employed with the control system disclosed in said patent have an inherent inertia, and while adequately responsive for toll checking, are prehaps limited in traffic counting installations to the relatively moderate speed range of normal pleasure driving. It may also be said that the maintenance and adjustment of mechanical relays requires a mechanic of high skill and experience because such relays are relatively delicate and precise tolerances of clearance of the contacts are usually essential to satisfactory operation. In other than large toll collection installations, it may be uneconomic to have a skilled mechanic in attendance, notwithstanding the fact that interruption of the functioning of the apparatus for even a short time may result in confusion in the count as well as loss of revenue.

The present invention utilizes a novel organization of thermionic tubes as switching means, in lieu of the circuit-closing relays of the previous system. It is well known that thermionic tubes

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are practically instantaneously responsive, and when employed as switching means have a speed range of response which no vehicular speed can defeat. Another desirable attribute of commercially available vacuum tubes is their high operating efficiency and trouble-free life expectancy, which materially exceeds that of the best of the mechanically actuated relays available for the purpose.

Generally speaking, it requires a mechanic having a much higher degree of skill to install or service a control system embodying a multiplicity of mechanical relays, than one basically involving vacuum tube circuits. Additionally, it is impossible to predict the operating life or performance of a mechanical relay apparatus even after an inspection wherein all of the mechanical relays were apparently functioning properly.

In an installation embodying the present invention, the vacuum tubes and the circuits thereof may be periodically inspected by a maintenance electrician who may have several installations under his care; and the characteristics of vacuum tubes are now so well-known that their useful life expectancy beyond the inspection day is predictable. At such periodic inspections, weak or doubtful tubes may be replaced at low cost—and barring accidental short circuits or damage to the electricity conductor system inherently present in any electrical installation—the satisfactory performance of the control system until the next inspection period may be confidently expected.

The present invention may be installed in an existing system of treadle plates, and therefore the control system installation pursuant to my said previous invention may be replaced by a system as later described herein, with resultant material increase in the speed performance of the system. The high speed response of a system embodying the present invention is of particular importance in installations on public highways, for example, where the objective may be to count vehicles, and the vehicles may be travelling at various speeds from slow to high.

It is an object of the invention therefore to provide a substantially trouble-free system for operation of a control or other electric device, responsive to sequential actuation of the switches of a multiple treadle or the like.

It is yet another object of the invention to provide an improved system for operating one or more counters responsive to actuation of a multiple switch treadle substantially only by an object rolling thereover and in accordance with

the forward or reverse direction of movement of such object.

A further object of the invention is to provide an improved system for operating a counter or other electrical device upon passage of a vehicle wheel over a multiple switch treadle, said system being capable of operation over a broad range of vehicle speeds without loss of accuracy.

Still another object of the invention is to provide a control system for operating an electrical device responsive to actuation of a plurality of switches in overlapping sequence, and in which the continuous closing of one of the switches by mechanical or electrical failure or by other means will not prevent proper operation of the electrical device by sequential actuation of the remaining switches.

A further object of the invention is the provision of an improved electrical system for operation by a multiple switch actuator to provide an output impulse responsive to actuation of the switches in a progressive sequence in which at least two of the switches are actuated concurrently, with a momentary overlap of three switches.

Another object of the invention is to provide a control system for operating an electrical device by the actuation of a multiple unit switch according to a predetermined sequence of operation of groups of the switches of said unit.

A still further object of the invention is to provide a control system for actuating an electrical work circuit pursuant to the closing of groups of switches in a pre-established sequence, and to insure against actuation of said work circuit by the operation of said switches in other than the predetermined sequence.

A further object of the invention is to provide means for indicating the number of times the switches of a multiple switch unit are closed in a predetermined sequence of operation of selected groups of said switches, and to disclose, by associated means, that groups of said switches are remaining in closed-circuit status for longer than a pre-established time period.

A further object of the invention is to provide means for the high speed counting of vehicles passing along a traffic lane.

Other features and advantages will hereinafter appear.

Fig. 1 is a schematic wiring diagram of a four treadle thermionic control circuit embodying the present invention. Fig. 2 is the treadle circuit, only, of an embodiment of the invention employing a three-switch treadle. A suitable source of 220 volt direct current is presumed to be available. In the figure, the plus symbols represent 110 volts D. C. above ground; the minus symbols represent 110 volts below ground; and ground, therefore, may be considered as substantially at zero potential.

When the invention, as illustrated in Fig. 1, is employed as a traffic control system, or, for example, in a toll-collection station, there is disposed across the roadway, traffic lane, or toll-collection lane, a multiple switch treadle T which has a series of contact plates A, B, C, D, arranged side by side and adapted to engage a common contact plate E individually when depressed as by the pressure of a vehicle wheel in rolling thereover. It will be understood that four separate plates may be used in lieu of the common plate E, so that the treadle may comprise four individual switches, if desired. Nevertheless, the four switches of the treadle T are

arranged closely side by side so that a vehicle wheel rolling over the treadle T will close the respective switches in an overlapping sequence in which at least two switches are closed concurrently, with a momentary overlap of three switches.

The treadle T may be made with the assembly of switches or plates suitably insulated and disposed within a flexible envelope or housing. The plates A, B, C, and D are preferably of relatively narrow width and of considerable length, extending across a traffic lane when the invention is used with road traffic. Said plates A, B, C, and D may be kept properly spaced laterally from each other and normally separated from plate E by suitable resilient separation strips or equivalent.

In the case of a wheel rolling from left to right, which is hereafter referred to as the forward direction, plate A will first contact with plate E, then plate B will contact with plate E, while A and E remain in contact, then plate C contacts with plate E, while A, B, and E are in contact. Plate D thereafter contacts with plate E, while B, C, and E remain in contact. All four plates need not be in contact with plate E concurrently, but sequential closure with a progressive overlap of closure of at least two is necessary for proper operation of the system described herein.

The function of the treadle switches is to provide means whereby the biasing potential in certain thermionic tubes may be regulated to control the periods of conduction and non-conduction of said tubes, as later described. There are numerous ways known to those skilled in the art for controlling the potential of a circuit; a simple and trouble-free method is by the use of resistance combinations.

Positive direct current is brought into a resistor **10**, preferably 90,000 ohms, and then through conductor **11** to 200,000 ohm resistors **12**, **13**, **14**, and **15** connected in parallel therewith. Said resistors are respectively in series with 5000 ohm resistors **16**, **17**, **18**, **19**, which connect to negative direct current. As appears, the respective plates A, B, C, and D are electrically connected to the four resistor circuits depending from the conductor **11**, intermediate the respective resistor pairs **12**—**16**, **13**—**17**, etc.

The resistors **16**, **17**, **18**, and **19** serve to preload the respective treadle plates A, B, C, and D to compensate for possible leakage in the treadle and to insure an established or calculable operative result from the treadle circuits when a vehicle passes over the treadle plates.

Branching from the conductor **11** is a conductor **20**, in series with which is a one megohm resistor **21** in a grid circuit of one triode of a dual triode tube VT**3** such as a standard 6SN7 tube. The respective operating halves of said tube will be designated VT**3***a* and VT**3***b*. The resistor **21** is in the grid circuit of VT**3***a*. The plate of VT**3***a* is connected to positive potential through a 25,000 ohm resistor **22**. From the said plate circuit extends a conductor **23**, which serves two mutually symmetrical vacuum tube circuits designated F and R, which respectively operate the forward and reverse counter means, provide protection against erroneous counts resulting from roll backs, etc., as later to be described. Said circuits are connected to the said conductor **23** in parallel electrical relationship.

Triode VT**3***a* of tube VT**3** is the primary control element of the circuit. Until it is rendered con-

ducting, the respective gaseous tubes VT4 and VT7, which control flow of power for actuation of the counters, cannot be primed for actuation. Until it is returned to non-conducting condition, the said tubes will not fire to operate the counter mechanisms which register forward or reverse travel of the vehicle across the treadle T.

When the respective treadle plates A, B, C, and D are in their normally open position, conductor 20 is at a high minus potential, because conductor 11 connects to the high minus polarity of the system through its respective branching circuits. The high minus potential maintains the grid of the triode VT3*a* at minus potential, and the triode is therefore non-conducting, in which circumstance its plate and the therewith connected conductor 23, have positive polarity.

The conductor 11 being connected to negative potential through the four parallel circuits, any one of the treadle plates may remain permanently closed with plate E, as might occur through jamming or like faulty operation, without raising the negative grid bias in the grid of tube VT3*a* sufficiently to cause the tube to conduct.

When two plates, such as A and B, are closed, the current path in the two associated branch circuits is to ground through plates A and B and the common, grounded treadle plate E, and the potentials in said branch circuits climb from the substantially minus 110 volt value to ground or substantially zero potential. The negative potential in the C and D branch circuits is insufficient to hold the potential in conductor 20 at minus and the grid of triode VT3*a* goes sufficiently positive to cause the triode to conduct to ground. The potential in conductor 23 drops substantially to ground level.

VT3*a* exerts control over two circuits which collectively energize the output device or devices according to a sequential or "coded" actuation of the treadle switches. One circuit is a "priming" or primary circuit. In applications of the invention to traffic counting systems, there may be a "forward travel" and a "reverse travel" counter, respectively FC and RC, and there will be an "F" and an "R" priming circuit, respectively electrically connected to conductor 23 through 23F and 23R. The "secondary" circuit is designated 23C, and serves the output devices through the respective capacitors 53 and 53R, as later appears.

Referring now to the F circuit, a dual triode vacuum tube VT1, the respective triodes of which are designated VT1*a* and VT1*b*, has its respective plates and grids interconnected in what is known to those skilled in the art as a thermionic toggle switch. The grid of VT1*a* connects through 400,000 ohm resistor 24 and conductor 23F, to conductor 23; intermediate resistor 24 and said grid is a branch comprising 400,000 ohm resistor 25 and a conductor 26 which connects to the plate circuit of VT1*b*. A second branch circuit connects to minus potential through the 800,000 ohm resistor 27. The plate circuits of VT1*a* and VT1*b* connect to positive potential through the respective 25,000 ohm resistors 28, 30.

As is characteristic of such interconnected triodes, when one triode in the circuit is conducting, the other is non-conducting. With any three of the treadle plates open conductor 23 is at high plus potential. The grid of VT1*a* is positive, and the tube is conducting. With VT1*b* non-conducting, its plate circuit is at high positive potential, increasing the plus bias on the grid of VT1*a*.

When plates A and B are closed with plate E, the potential in conductor 23 goes to ground, but the positive potential in conductor 26 keeps enough positive bias on the grid of VT1*a*, to keep the tube conducting. Conductor 29 is at ground potential, and the negative potential exerted on the grid of VT1*b* through the two megohm resistor 31 holds triode VT1*b* non-conducting.

Attention is now directed to the second of the dual triode tubes in the F circuit, designated VT2. Its operating triodes are designated VT2*a* and VT2*b*, respectively. It will be noted that the grid of VT2*a* connects to positive power through the 7 megohm resistor 32, and to the respective conductors 33 and 34 of the A and B treadle circuits through the 2 megohm resistor 35 and the respective 200,000 ohm resistors 36 and 37. When the treadle plates A or B are open, the grid of VT2*a* is negative because of the high negative potential of the A and B treadle circuits, and the tube is non-conducting. When plates A and B are closed, conductors 33 and 34 go to ground potential, and the high plus bias exerted on the grid by its positive potential connection causes the tube to conduct.

Circuits F and R are interlocked through a thermionic toggle switch in R which is identical with that of VT1. The dual triode tube of said circuit is designated VT5 and its respective triodes VT5*a* and VT5*b*. Before the closure of plates A and B, tube section VT5*a* was conducting and tube VT5*b* was non-conducting. It is noted that conductor 38 connects the plate of VT2*a* with the positive potential in the plate circuit of VT5*b* and hence tube VT2*a* receives positive power from tube VT5*b*. With tube VT2*a* conducting when the plates A and B are closed, the cathode of VT2*a* follows the grid to a positive potential level. The cathode connects through conductor 39 and 200,000 ohm resistor 40 to conductor 41 and puts positive potential in said conductor. With conductor 29 at ground, conductor 42 in the grid of VT1*b* goes positive, and tube VT1*b* conducts, reducing the potential in conductor 26 to ground. With both conductors 23 and 26 then at ground potential, the grid of VT1*a* goes negative and the triode VT1*a* is non-conducting.

The conductor 29 goes positive, and through one megohm resistor 43 maintains a plus grid bias on triode VT1*b*, holding it conducting.

In the described circuit, therefore, when the tube VT1*b* is conducting, it signifies that the vehicle is travelling over the treadle in a forward direction. When the wheel of the vehicle continues to roll forward, it engages plates B and C before plate A is released; and the combination of the closed plates B and C maintains the circuits of VT3*a* and VT1 in the same operative status as when plates A and B were closed.

WT2*b*, the other triode of VT2 has its plate circuit connect with the plate circuit of tube VT1*a* through conductors 29, 44, and 200,000 ohm resistor 45, and with VT1*a* non-conducting, conductor 44 and the therewith associated plate of VT2*b* have a plus potential.

The grid of VT2*b* connects to positive power through conductor 46 and 400,000 ohm resistor 47; it also connects to the respective A and B treadle connections 33, 34, through conductor 48 and the respective 200,000 ohm resistors 49, 50. The cathode of VT2*b* connects to ground. With A and B closed, tube VT2*b* becomes conducting to ground and tube VT1*a* being non-conducting, conductor 44 has a plus potential, but conductor 51 on the far side of the plate circuit of tube

VT2*b* is at ground potential. When A or B is opened, VT2*b* returns to non-conducting. With the momentary overlap of three plates, C will be closed when A or B is opened; VT1*a* continues non-conducting and conductor **51** goes to plus.

Conductor **51** connects to a voltage divider comprising one megohm resistor **52** and 600,000 ohm resistor **53**, the latter connecting to negative potential through conductor **54**. The grid of gaseous tube VT4 connects via 25,000 ohm resistor **55** and conductor **56**, to the voltage divider. With ground potential at conductor **51**, there is a minus potential of about 70 volts on the grid of VT4. When A or B is opened and VT2*b* becomes non-conducting, the negative bias of the grid of VT4 is reduced to approximately 40 volts, priming the tube for firing.

A capacitor divider comprises .0005 mfd. capacitor **57** and .0003 mfd. capacitor **58**, one side of each being connected to conductor **56**.

Capacitor 57 connects to ground and capacitor 58 connects with conductor **23** through conductor 23C, as shown.

When treadles A, B, and C are opened, tube VT3*a* reverts to non-conducting condition and hence conductor **23** goes rapidly positive. Capacitor divider **57**, **58** puts a plus surge in the grid circuit of gaseous tube VT4, sufficient to raise its grid bias and to fire the tube.

Thus the opening of treadles A and B, or either of them, primes tube VT4 for firing, and the opening of treadle C provides the necessary impulse for firing the tube.

VT4 is an 884, in which anything less than minus 10 volts bias on the grid will fire the tube. A larger solenoid or other output device may require a higher capacity thyratron tube and other values in the capacitor divider, as known to those skilled in the art.

Tube VT4 firing, it remains conducting through the solenoid FC, providing the current to draw the ratchet 60 thereof upwardly to rotate the number wheel 61 an amount sufficient to advance the counter one digit. A back contact **62**, which is in series between ground, conductor **63**, resistor 64 and the cathode of tube VT4 is operatively associated with ratchet **60**, as by a lost-motion link 65. As the ratchet **60** completes its upward movement, contact 62 is opened, allowing the cathode potential to climb positively until the grid regains control and tube VT4 extinguishes.

Capacitor 67 holds the plus potential on the cathode for a sufficient time to insure complete deionization of the tube and for the potential and capacitor divider discussed above to restore to the approximately —70 volt bias. Current flow through solenoid FC ceases as the tube is extinguished and its ratchet moves downwardly under the urging of spring **66** to engage for the next counter operation.

The downward movement of the ratchet **60** ultimately closes the back contact **62**, to bring the cathode of tube VT4 again to ground potential. The system is ready for the next forward count.

The reverse travel circuit R is a duplicate of the forward circuit, in the types of vacuum tubes and their respective positions in the circuit, and in the values of the respective resistors and capacitors associated therewith. A detailed description of the reverse circuit is believed unnecessary. It will be understood that the reverse travel of a vehicle across the treadle is from right to left, whereupon the order of actuation of the treadle plates is the reverse of that previously described.

Resistors and capacitors which are exact counterparts of those in the F circuit have been numbered as in the F circuit, with the addition of the letter "R."

Tube VT6 is the counterpart of VT2, and the triodes VT6*a* and VT6*b* thereof perform the same function as the triodes VT2*a* and VT2*b*. VT6*a* is connected to plates C and D through the 2 megohm resistor **70**, and the respective 200,000 ohm resistors **71**, **72** and conductors **73**, **74**. VT6*b* is connected to plates C and D through the 200,000 ohm resistors **75**, **76**, and the respective conductors **73**, **74**.

The F and R circuits are interlocked by the conductor **77** which connects from the plate circuit of VT1*b* to the plate of VT6*a*. The latter triode gets positive potential from the plate circuit of VT1*b* when triode VT1*b* is non-conducting status. Similarly as in VT2*a*, the cathode of VT6*a* places a positive bias on the grid of triode VT5*b* which in turn biases triode VT5*a* to non-conducting status.

In the reverse travel, the closure of plates D and C makes the triode VT3*a* conduct, just as did the closure of the plates A and B in the forward direction of travel. Similarly, the closure of plates C and D causes the respective triodes VT6*a* and VT6*b* to become conducting, thereby impressing an approximately minus 70 volt potential on the grid of VT7, and the release of either plate C or D causes triode VT6*b* to become non-conducting to raise the negative bias on VT7 to approximately 40 volts, priming the tube for firing.

The gaseous tube VT7 fires by reason of the plus surge introduced into the grid of tube VT7 through the capacitor divider **58R**, **57R**, as tube VT3*a* becomes non-conducting, sending conductors **23**, **23C** rapidly to positive potential, following the opening of plate B as the wheel rolls across the treadle.

When VT7 fires current flows through the reverse solenoid RC, through the tube, resistor **64R**, conductor **63R**, back contact **62R**, to ground. As the ratchet **60R** of reverse counter wheel **61R** rises fully, the lost motion link **65R** connecting the ratchet **60R** and back contact **62R** causes the said back contact to open to permit the cathode to go positive and to extinguish the tube, and halt current flow through solenoid RC, whereupon spring **66R** resets the reverse counter for the next action.

It is apparent, therefore, that in either the forward or reverse travel of a vehicle across the treadle the operation depends upon having two plates closed concurrently, with a momentary overlap of three plates. The fourth plate in the treadle is a "spare" so that if any one of the others is held permanently closed, the operation of the system will be unaffected.

In the case of an axle counting system for toll checking the treadle is placed a short distance beyond the toll station so as that the car wheels will cross the treadle after toll is paid and the car moved forward in leaving the toll station. However, the restriction of the traffic lanes at and near the toll station to permit cars passing around or crossing lanes extends for only a short distance and the treadles cannot be placed very far beyond the station. For this reason car drivers sometimes overrun the station somewhat and actuate the treadle in a forward direction and then back up to pay toll, again proceeding forward over the treadle after paying toll.

The present construction provides for this condition by the count in both the reverse and for-

ward directions so that the forward count less the reverse count provides an accurate net forward count.

Another problem in toll check counting is that the front wheels of a car may roll partway onto the treadle. Such a condition is sometimes also caused by the toll collector's recalling the driver on account of an error in change or some other question about the money or the driver returns to ask some question.

It is a feature of the present construction that such rolling back and forth will not interfere with a correct net forward count.

In a situation wherein a vehicle ran forwardly over the treadle sufficiently only to close plates A and B with E, and then rolled back to open either A or B, it is obvious that the thyratron VT4 could not fire and there would be no forward count. If the vehicle has rolled onto A, B, and C, then rolls in reverse direction to open contact C only, the thyratron will not have primed, and could not fire. If the vehicle rolls forwardly to the B and C combination, then rolls back to close A and B again, the thyratron, having been primed as the vehicle rolled forwardly, will deprime, and there will be no actuation of the forward counter solenoid FC. The completion of the circuit for actuating the counter depends on a rolling forward over plates A, B, and C in succession, and a breaking of the C plate connection as well as a breaking of either the A or B plate connection.

The present invention provides for indicating that the treadle system or the circuits associated therewith have been tampered with or operated in such manner as to hold two or more of the treadle circuits continuously closed for a fixed period of time. Said time period is longer, of course, than the substantially momentary closure caused by a vehicle rolling over the treadle, even at a very low speed. A reasonable time limit of continuous, concurrent closure of two contacts or associated circuits has been arbitrarily established as five seconds. If two or more of the treadle plates are closed for more than five seconds, suitable signalling and/or recording means operates to indicate such prolonged closure.

The triode VT3*b* operates as a delayed switching means in an indicating or recording circuit. The grid of VT3*b* is connected to negative potential through the resistor 90, and its plate is connected to positive potential by a circuit which includes the relay coil 91. A conductor 92 connects to the conductor 23 from the plate circuit of triode VT3*a*, and thence, through resistor 93, to the grid circuit of triode VT3*b*.

It will be recalled that with none, or only one of the plates A, B, C, or D closed with plate E, triode VT3*a* was non-conducting and there was a positive potential in conductor 23. This positive potential is also present in conductor 92, and is sufficient to positively bias the grid of VT3*b*, so that the latter triode is normally conducting. The relay 91 is therefore energized and its armature 94, which is connected to a source of current is held out of engagement with the contact 95 which is in circuit with a lamp L, a printer PRT or a bell BL. Hence, with triode VT3*b* conducting, none of the illustrated signalling or printing means will be energized.

As soon as two or more of the four treadle plates is closed with plate E, tube VT3*a* conducts and the potential in conductor 92 is reduced to ground. The reduction to ground potential in conductor 92 is not immediately apparent in the grid of VT3*b*, because of the condenser 96 in the grid circuit which, having a positive charge impressed thereon while conductor 92 was positive, discharges when conductor 92 goes to ground, delaying the reduction to negative potential in the grid circuit of VT3*b*. Depending upon the capacity of the condenser and the values of the resistors 90, 93, the reduction of the grid of VT3*a* to sufficient negative bias to stop the conducting action of triode VT3*b* may be delayed as desired. After the time period has run, the grid of VT3*b* goes to negative, the triode ceases to conduct and the relay 91 is deenergized, permitting the armature thereof to drop out and to complete the circuit through the respective apparatus L, PHT, BL, to actuate the same and thus to signal that the system is being tampered with or is operating improperly.

It is frequently the practice in toll collection installations, to have a printer, such as PRT, print on a tape at regularly established time intervals, such as every half hour or every hour. If a supervisor, in examining the printed tape record, finds that the apparatus has printing intermediate the established times, it is an indication that the operation of the treadle has either been faulty, or has been tampered with, during such period, and steps may be taken to correct the error.

Fig. 2 discloses a circuit diagram, only, of a three treadle switch mechanism in which A and D are the same as the similarly identified switches of Fig. 1, and X is the center switch which may be considered as a combination of B and C of Fig. 1. In the three treadle circuit, the resistors 12′, 13′ and 15′ each have one half of the value of the switches 12, 13, and 15, of Figure 1. The leads 33 and 74 connect with switches A and D, just as in the Fig. 1 circuit. The lead to the X switch of Fig. 2, is the combination of leads 34 and 73, in the Fig. 1 circuit. In other words, when the three treadle circuit is employed, the respectively identified leads 34 and 73 are combined and brought to the X switch.

The operation of the three switch treadle is identical with that of the four switch system, except that none of the three switches may be held permanently closed. The safety factor of operation characteristic of the four switch circuit is therefore absent in the Fig. 2 embodiment.

In recapitulation, it is seen that the grid of the respective gaseous tubes VT4 and VT7 is under the control of vacuum tube switching means operating in a predetermined and controlled sequence by the concurrent closing of two switches of a multiple switch system, with a momentary overlap of closing of at least three of said switches.

Of the respective electronic tubes: VT4 constitutes a switch in the counter or other work circuit; in the appliaction of the invention described herein, said tube controls flow of power to the forward counter device.

VT7 is the reverse-direction counterpart of VT4.

VT3*a* unlocks the circuit for operation when any two of the switches are closed concurrently, and provides the pulse for actuating the counter device power tube.

VT1 is the dual triode which indicates closure of the switches in a left to right direction; VT5 similarly indicates closure in right to left direction. Additionally, VT1 and VT5 reset the tubes of the actuating circuits when at least three switches of a four switch system, or all of a three

switch treadle, are returned to open-circuit position.

VT2*a* and VT6*a* respectively select the proper counter circuit for forward and reverse travel indication.

VT2*b* and VT6*b* respectively prepare the priming grid bias for the respective forward and reverse counter actuating tubes VT4 and VT7.

There are four stages of control circuit operation for each actuation of the respective thyratron tube VT4 or VT7.

Initially, that is, with at least three of the four switches of the Figure 1 embodiment open, or with all of the three switches of the Fig. 2 embodiment open, the control circuits are "locked." Taking the F circuit as typical, VT4 is secured against operation by reason of the direct ground connection through VT1*a*, which places ground potential in conductors 29, 44, and 51. The high negative potential in conductor 54 therefore holds the grid of VT4 at high negative bias.

The second stage is preparatory, in which when plates A and B are closed, the path to ground at VT1*a* is interrupted, and positive potential is present in conductors 29, and 44. However, with switches A and B closed, tube VT2*b* becomes conducting to ground, and hence conductor 51 is at ground potential. The high negative in conductor 54 maintains the high bias on VT4.

Thirdly, there is a priming stage, which occurs when either switch A or B opens, whereupon VT2*b* is non-conducting, and conductor 51 goes positive. The voltage divider effect of resistors 52, 53 reduces the grid bias of VT4 to approximately 40 volts. The closure of switches B and C, or C and D, maintains tube VT3*a* conducting to ground.

During the two stages immediately above, the thermionic toggle interconnection of the tubes VT1*a* and VT1*b* maintains VT1*a* in non-conducting condition.

The final or firing stage occurs when switch C is opened during continuing movement of the vehicle in one direction. Tube VT3 reverts to non-conducting and a plus surge from the switch circuit of VT3*a* is impressed upon the capacitor 58, resulting in a strong plus surge in the grid circuit of VT4 sufficient to cause the tube to conduct and hence to energize the counter or indicator. In the interim immediately following the opening of switch C, tubes VT1*a* and VT1*b* have toggled to their original operative status—that is, their operating condition before the vehicle began travel across the treadle—but the delaying action of the several resistors in the F circuit restrains the return of the high bias condition of VT4 until after the positive surge has occurred across capacitor 58. As is well-known, when an electronic tube of the thyratron type commences to fire, the grid alone is ineffective to gain control over the tube to extinguish it. In order to extinguish tube VT4 and to restore the entire circuit to its original locked position, the cathode of VT4 is permitted to climb in a positive direction by disconnecting the cathode from ground, through the delayed opening of the back contact 62. As the cathode connection to ground is opened, the climbing cathode extinguishes the tube to permit the grid thereof to resume control; the circuit is ready for the next operation.

It will be recalled that the plate of tube VT2*a* derives positive power from the plate circuit of VT5*b* through conductor 38, and that the plate of tube VT6*a* derives positive power from the plate circuit of VT1*b*, through conductor 77. When switch plates A and B are closed, tube VA2*a* became conducting and current flowed through conductors 38, 39, 41, and 42 to the grid of VT1*b* causing VT1*b* to become conducting and to toggle VT1*a* into non-conducting condition. As switches A and B, or either of them, are opened, VT2*a* returns to non-conducting, but there is enough plus reaction through conductor 29 and resistor 43 to hold conductor 42 sufficiently plus to maintain VT1*b* in conducting status. The closure of switches C and D by the vehicle passing thereover brings the grid of VT6*a* to conducting bias, but since VT1*b* is continuing to conduct to ground, there is ground potential in conductor 77 and tube VT6*a* is locked in non-conducting condition.

If the A and B treadle switches are the first to close, therefore, VT5*a* cannot be toggled to non-conducting condition, and the "R" circuit is locked against operation of its associated thyratron VT7.

For vehicles travelling in the reverse direction, the closure of switches D and C would initiate operation of the R circuit and the F circuit would be locked against operation of thyratron VT4.

Therefore, it is apparent that the operation of the F or R control circuits depends upon which of the pairs of switches AB, or DC, is first closed by the vehicle in passing over the treadle.

In the foregoing description, and in the claims, the expressions "conducting" and "non-conducting" are used in describing the operative status of the respective vacuum tubes. A "conducting" tube is considered to be one in which the grid bias permits substantial current flow between the plate and cathode of the tube; a "non-conducting" tube has a grid bias which prevents such flow.

It will be understood that the circuit specifically disclosed herein, and the constants and values ascribed to the disclosed resistors and capacitors, are not recited in a limiting sense, but are illustrative of a circuit which satisfactorily performs the features and objectives of the invention.

Whereas it is obvious that the several objects of the invention as specifically afore noted are achieved, it is apparent that numerous changes in construction and rearrangements of the elements might be resorted to without departing from the spirit of the invention as defined by the claims.

I claim:

1. Means for counting vehicles proceeding along a traffic lane, including a switch unit having at least three switches so spaced that a vehicle wheel travelling thereover in a continuing direction will close two switches simultaneously, with momentary overlapping closure of three; an electrically energized counter; an electrically potentialized circuit connected therewith for actuating the same, and means for establishing, in stages, a priming potential and an actuating potential in said circuit; said means including vacuum tube toggle switching means electrically in circuit with said switches and normally stable, with any two of said switches open, to connect said actuator circuit to ground by vacuum tube conduction and having a second condition of stable equilibrium to interrupt said ground connection when any two of said switches are closed; vacuum tube means electrically in circuit with all three of said switches and with said toggle switching means to prepare the latter for transition to said second condition of equilibrium so long as any two of said switches are closed; a second vacuum tube means electrically in circuit with the two switches first closed by a vehicle in passing over said switch unit and

in circuit with said toggle switching means to bias the latter to its said second position of equilibrium as said two switches are closed; a third vacuum tube means electrically in circuit with said first-closed two switches for restoring connection between said actuator circuit and ground by vacuum tube conduction as said two switches are closed and interrupting said ground connection as one of said two switches is opened during travel of the vehicle over said switch unit; voltage divider means in said actuator circuit to maintain a counter non-operating potential therein while said circuit is grounded and upon interruption of said ground connection to prime the potential in said circuit to a value and polarity approaching a threshold value of operation of said counter; and means electrically connected to said actuator circuit and energized from said first-named vacuum tube means as the third of said switches is opened upon continuing travel of said vehicle to momentarily raise the potential in said circuit to above the threshold level for operation of the said counting means.

2. A traffic counter including at least three normally open switches disposed in a traffic lane in such spaced relationship that a vehicle wheel in passing thereover will close said switches in sequence with momentary overlapping closure of three switches; electrically energized counting means, a thermionic tube for controlling current flow to said counting means, and a potentialized control circuit for the grid of said tube for establishing a grid bias thereof for actuation of said counting means upon coded closure of said switch means; comprising in said grid circuit a pair of vacuum tubes interconnected in toggle circuit relationship, one of the said vacuum tubes arranged to connect said grid control circuit to ground by vacuum tube conduction; a second vacuum tube electrically in circuit with said three switches and with said toggle-connected vacuum tubes to establish the ground connection of the grid control circuit when said switches are in open-circuit position and to prepare said toggle switching means for interruption of said connection to ground upon closure of two of said switches; a third vacuum tube means electrically in circuit with the first two of said switches to close upon travel of a vehicle thereover and in circuit with said toggle-connected tubes to bias the said ground conducting tube to non-conducting status upon closure of said two switches; a fourth vacuum tube means in said control circuit for establishing a second ground connection therefor by vacuum tube conduction upon closure of said first-closed two switches and interrupting said connection upon return of either of said two switches to open condition; voltage divider means in said control circuit and effective while the control circuit is grounded to place a high bias on the grid of said thermionic tube and upon interruption of said ground connection bring said grid nearly to a threshold level of thermionic tube conduction; and means electrically in circuit with said second named vacuum tube and with said grid control circuit to momentarily impress additional potential in said grid control circuit to carry the grid over the threshold level of operation of said tube as the third of said switches is opened.

3. Means for indicating direction of travel of a vehicle along a traffic lane, comprising a forward travel indicator; a reverse travel indicator; an electrically potentialized actuator circuit individual to each said indicator for actuating the same; and means for energizing a selected actuator circuit to establish, in stages, a priming potential and an operating potential to actuate the indicator thereof, including in each actuator circuit vacuum tube toggle switching means having a condition of stable equilibrium connecting said circuit to ground by vacuum tube conduction and a second condition in which the ground connection is interrupted; a switch unit including at least three normally open switches disposed in said traffic lane in such spaced relationship that a vehicle wheel travelling thereover in a continuing direction will close said switches in groups of two with momentary overlapping closure of three switches; vacuum tube means controlled by said switch unit and connected to each said actuator circuit to lock the toggle switching means thereof in circuit grounded condition when the switches of said unit are open and upon closing any two of said switches to unlock the toggle switching means for toggling to the other condition of equilibrium; vacuum tube means for the forward-travel actuator circuit connected to the toggle switching means thereof and in circuit with the pair of switches first closed by a forward-travelling vehicle; vacuum tube means similarly connected in the reverse-travel circuit and in circuit with the pair of switches first closed by a reverse-travelling vehicle, the closure of one of said pairs of switches biasing its associated last-named vacuum tube means into conducting condition to actuate its associated toggle switch to ground disconnect condition; means for holding the toggle switch of the other circuit in ground connect status, further vacuum tube means in each actuator circuit and respectively controlled by the forward-travel switch pair and the reverse-travel switch pair, said further vacuum tube means being operative to restore its associated ground-interrupted actuator circuit to ground connection by vacuum tube conduction upon closure of its associated two switches and to interrupt the path to ground upon the return of one of said switches to open condition as the vehicle continues its travel; voltage divider means in each said circuit effective upon the final ground disconnect condition of the forward or reverse actuator circuit to establish therein a preparatory value and polarity of potential approaching a threshold value for operating the indicator of said circuit; means in said actuator circuit and deriving power from the first-named vacuum tube means for momentarily impressing additional potential to momentarily raise said circuit to above said threshold level for actuation of said indicator.

4. Means for indicating direction of travel of a vehicle along a traffic lane, comprising a forward travel indicator; a reverse travel indicator; an actuator circuit individual to each indicator for actuating the same; a source of positive potential and a source of negative potential connected to each said actuator circuit; and means for establishing a potential in said circuits sufficient to actuate its associated indicator according to direction of vehicle travel, including: in each actuator circuit a pair of vacuum tubes interconnected to provide vacuum tube toggle switching means having a condition of stable equilibrium in which the positive potential in the associated actuator circuit is neutralized by vacuum tube conduction to ground and a second condition of equilibrium in which said ground connection is interrupted; a switch unit including a plurality of normally

open switches disposed in said traffic lane and arranged to be closed in grounps of two switches with momentary overlapping closure of three switches by a vehicle travelling thereover in a continuing direction; electric potential means in circuit with said switch unit and with each of said pairs of vacuum tube toggle switching means to bias the same in ground connection condition thereof when the switches of said unit are in open circuit position and to reduce the bias to prepare said toggle switching means to toggle to their other condition of equilibrium upon closure of any two of said switches by a vehicle travelling over said switch unit; a second vacuum tube means in each actuator circuit and respectively in circuit with and energized by the two switches first closed by a vehicle traversing said switch unit in a forward or reverse direction, said latter vacuum tube means of each actuator circuit being in circuit with the toggle switching means of its actuator circuit to bias said means to toggle to ground-interrupt condition according to which pair of switches is first closed by said vehicle, the vacuum tube means associated with such first closed two switches deriving its biasing potential from an element of the toggle switching means of the other actuator circuit to hold said latter toggle switching means at ground-connect status; further vacuum tube means in each of the two actuator circuits in advance of the negative potential source thereof, each said latter vacuum tube means being respectively controlled by the first two switches closed by a vehicle travelling in a forward or reverse direction and adapted to restore the ground connection of its associated actuated circuit upon closure of the said two switches and to interrupt the ground connection upon the return of one of said two switches to open condition as the vehicle continues its initial direction of travel; voltage divider means electrically connected between the respective sources of positive and negative potential to establish a potential in the actuator circuit approaching the threshold level of actuation of the indicator as the last named connection to ground thereof is interrupted, and means deriving power from the electric potential means in circuit with said switch unit for momentarily carrying the potential in said actuator circuit above the threshold level to actuate the associated direction indicator as a third switch of said switch unit is opened as the vehicle continues its travel over the switch unit.

5. A traffic counting system including electric counting means having a relatively fixed lower limit of operating potential, and means for controllably establishing said operating potential, comprising a priming circuit having a normal potential which is less than such operating potential, and a supplemental circuit capable of momentarily impressing additional potential to additively equal or exceed such operating potential; said priming circuit including a thermionic toggle switch having a condition of stable equilibrium bypassing said circuit to depress the normal potential thereof and a second condition interrupting said bypass; a normally non-conducting vacuum tube in said priming circuit for establishing a second potential-depressing bypass by vacuum tube conduction; a biasing circuit common to said toggle switch and said vacuum tube and having a potential normally biasing said toggle switch to its first condition of equilibrium and said vacuum tube to non-conducting status; vehicle actuated means for changing the potential in said biasing circuit to throw said toggle switch to its said second condition and simultaneously to bias said vacuum tube to conducting status; a second biasing circuit including a second vehicle-actuated means actuated sequentially after the first-named means for holding said toggle switch in its second equilibrium condition while the return of said first-named vehicle actuated means to initial status restores said vacuum tube to non-conducting status to establish the normal potential of said priming circuit; and means electrically connecting said last-named vehicle actuated means and said supplemental circuit and responsive to return to initial status of said last-named vehicle actuated means to momentarily potentialize said supplemental circuit to increase the potential in said counting means sufficiently to operate the same.

6. A traffic counting system according to claim 5, in which said supplemental circuit includes capacitor means charged during actuation of said second-named vehicle actuated means and discharging into said counting means upon restoration of said vehicle actuated means to initial status.

7. A traffic counter, including electrically energized counting means; a normally non-conducting gaseous thermionic tube in the electrical circuit of said counting means and adapted to energize said counting means when said tube is conducting; a vehicle-actuated treadle embodying a plurality of switches for sequential actuation by a vehicle wheel rolling over the treadle in a continuing direction; and an electric circuit in the grid circuit of said thermionic tube and controlled by the said switches, said circuit including electronic switching means connecting the grid of said thermionic tube to a high negative potential as certain of said switches are actuated by said vehicle wheel, voltage divider means effective upon the release of one of said switches and the actuation of another switch to reduce the grid bias of said thermionic tube; and further electronic switching means electrically connected to said switches and including a capacitor divider in the grid circuit of said thermionic tube and said last named means being effective upon the release of said last-named switch to place a plus surge on the grid of said tube sufficient to cause the same to become conducting.

8. Means for counting the passage of vehicles along a traffic lane, comprising a switch unit of at least three switches disposed at a fixed location in said traffic lane in such spaced relationship that a vehicle passing said location will sequentially actuate said switches with momentary overlapping actuation thereof; an electrically energized counting means; a control circuit for said counting means, including potential divider means for providing an electrical potential of slightly less than energizing level of said counting means upon the actuation of two of said switches and the return to initial status of one of said two switches as a vehicle passes thereover; a second control circuit responsive to the concurrent actuation of a second and third of said switches to cause the first-named control circuit to maintain such electric potential; and means electrically associating said second control circuit and said counting means to increase the electrical potential at said counting means to a value sufficient to energize the same as all of the said three switches return to normal status as the vehicle proceeds beyond the switch unit.

9. A vehicle-operated system for actuating electrically energized counting means, comprising a gaseous triode functioning as a normally non-conducting element in series in the circuit of said counting means; a grid control circuit for said triode; a plurality of electric switches adapted upon passage of a vehicle thereover to be sequentially closed with momentary overlapping closure of all switches; means responsive to the closing of certain of said plurality of switches to impress a high negative bias on the said grid circuit to prevent conduction in said tube; means responsive to the subsequent opening of at least one of said switches and the simultaneous closing of another switch to reduce the grid bias from such high negative value to a point approaching but not attaining a level sufficient to cause said triode to become conducting, means responsive to the opening of said last-named switch while keeping at least one of said first-named switches open to further reduce the grid bias of said triode from such point to a level at which said triode becomes conducting in said work circuit and said counting means is actuated; a switch operatively associated with said counting means and normally connecting the cathode of said triode to relatively low potential; and means responsive to operation of said counting means to open said switch to permit the cathode to climb positively to a potential at which the grid of said triode regains control thereover.

10. A system for controlling an electric work circuit, comprising a gaseous triode functioning as a normally non-conducting element in series with said work circuit; a grid control circuit for said triode; a plurality of electric switches arranged for sequential operation, with momentary concurrent operation of all switches; a source of positive and a source of negative potential for said control circuit; means responsive to the closing of a group of said plurality of switches to bypass the positive potential of said control circuit to permit the negative potential to impress a high negative bias in the grid circuit of said triode to prevent conduction therein; means responsive to the subsequent opening of at least one of said group of switches and the simultaneous closing of another switch to supersede such high negative bias and to establish the grid bias at a point approaching but not attaining a level sufficient to cause said triode to become conducting; means responsive to the opening of said last-named switch while keeping at least one of said first-named switches open to shift the grid bias of said triode from such point to a level at which said triode becomes conducting; and means effective consequent to the conducting condition of said triode to permit the grid of the triode to regain control thereover.

11. In a vehicle actuated counting system, a switch unit disposed in a traffic lane and having a plurality of switches so disposed that a vehicle travelling thereover closes said switches in sequence, with momentary overlapping closure of all; a counting means responsive to coded closure of said switches by a vehicle in travelling in one direction over said switch unit; a second counting means responsive to coded closure of said switches by a vehicle in travelling in the opposite direction, and means for selectively actuating the counting means according to direction of travel, including a control circuit for each said counting means; a double triode thermionic toggle in each said counting means circuit and normally in a condition of equilibrium holding its associated

counting means circuit at non-operating potential when all of said switches are open; vacuum tube means electrically associated with said switches and a triode of each said thermionic toggle to prepare each said toggle upon closure of any two of said switches to assume a condition of equilibrium in which each said counting means circuit may be supplied with operating potential; and a third vacuum tube means in each said counting means circuit and respectively electrically connected to those two switches first closed by a vehicle travelling over said switches in one or the other direction and with the toggle of said circuit to throw the toggle to its said second condition of equilibrium upon the closure of the said two switches, each said last-named vacuum tube means deriving its operating potential from a triode of the toggle of the opposite counting means circuit.

12. In a vehicle actuated counting system having counting means respectively responsive to forward or reverse travel of a vehicle, means for selectively actuating said counting means, including a switch unit having at least three normally open switches so disposed in a traffic lane that a vehicle passing thereover closes said switches in groups of two with momentary overlapping closure of three switches; an electric circuit for each said counting means, and each circuit being electrically controlled by a different group of two of said switches; a thermionic toggle switch in each said circuit and having one condition of equilibrium in which the respective circuits are held at a potential precluding operation of its associated counting means and a second condition of equilibrium wherein the respective circuits may be brought to operating potential, vacuum tube means actuated by the closure of any two of said three switches and connected to each said thermionic toggle switch to prepare each for transition to its second condition of equilibrium upon closure of any two of said switches; and means in each of said counting means circuits and electrically associated with the toggle switch thereof, said means controlling a source of electrical potential and responsive only to the closure of the group of two switches associated with its said counting means circuit to impress said potential on the associated toggle switch to cause said toggle switch to assume its said second condition of equilibrium, said potential being derived from an element of the toggle switch of the opposite counting means circuit.

13. In a system for counting the number of vehicles passing along a traffic lane, a switch unit disposed in said lane and comprising a plurality of switches so arranged that a vehicle wheel rolling over said unit will close said switches in sequence; means for counting the number of vehicles passing over said switch unit in one direction; a second means for counting the number of vehicles passing over said switch unit in the opposite direction; control circuits for each said counting means; vacuum tube means having its plate circuit in parallel with each of said control circuits, said vacuum tube means being controlled by said switches to conduct from positive potential to ground with certain of said switches in closed circuit position and being non-conducting to ground with said switches in open circuit position; and means for indicating a prolonged closure of said switches, comprising indicating means, a magnetic switch for controlling said indicating means, a second vacuum tube means having its grid biased to conducting potential by the plate

potential of said first-named vacuum tube means when the latter is in non-conducting status, said second vacuum tube means, when conducting, actuating said magnetic switch for non-operation of said indicator; and time delay means in the grid circuit of said second vacuum tube means to impress a non-conducting bias on the grid thereof at a predetermined period of time after the first-named vacuum tube becomes conducting upon closure of said two switches; a non-conducting condition of said second vacuum tube actuating said magnetic switch to close the circuit to said indicator.

14. In a system for counting the passage of vehicles along a traffic lane, a switch unit disposed in said traffic lane and comprising a plurality of switches so arranged that a vehicle rolling over said unit will close said switches in sequence; an indicator and control circuit therefor; a relay in said control circuit; and vacuum tube means in circuit with said relay and energizing the same for holding said indicator circuit open while said vacuum tube means is conducting and deenergizing said relay to close said indicator circuit when said tube means is non-conducting; a biasing potential for the grid circuit of said vacuum tube; means operating with said switches in open circuit position to bias said grid to conducting condition and with certain of said switches in closed position to bias said grid to non-conducting condition; and means for delaying the transition from conducting to non-conducting condition of said grid following closure of said switches.

15. In a system for counting the passage of vehicles along a traffic lane, a switch unit disposed in said traffic lane and comprising a plurality of switches so arranged that a vehicle rolling over said unit will close said switches in sequence; an indicator and control circuit therefor; a relay in said control circuit; and vacuum tube means in circuit with said relay and energizing the same for holding said indicator circuit open while said vacuum tube means is conducting and deenergizing said relay to close said indicator circuit when said tube means is non-conducting; a biasing potential for the grid circuit of said vacuum tube; means operating with said switches in open circuit position to bias said grid to conducting condition and with certain of said switches in closed position to bias said grid to non-conducting condition; and a resistor and capacitor circuit in said grid circuit for delaying the transition from conducting to non-conducting condition of said grid following closure of said switches.

16. In a traffic counting system including counting means, switch means in a roadway and embodying a plurality of switches for momentary overlapping closure by passage of a vehicle wheel thereover and means whereby such momentary closure prepares said counting means for actuation, means for indicating a prolonged closure of said switches, comprising an indicator, an electric circuit therefor, vacuum tube means in said circuit to control current flow therethrough, a grid control circuit for said vacuum tube electrically in circuit with said switches, electrical potential means in circuit with said switches and said grid circuit to bias the grid of said tube for vacuum tube conduction when said switches are open and to bias said tube to cut off upon closure of said switches, said grid control circuit having resistance and capacitance means to delay the impression of cutoff bias on said tube for a predetermined time period after closure of said switches; and means responsive to the cutoff of said vacuum tube to operate the indicator.

17. An electrical network for energizing an output device having an established lower limit of operating potential, comprising a first and second energizing circuit connected to the input of said device, each said circuit being potentialized to supply to the device a potential which is less than its operating potential, but additive to the required value; a first and second vacuum tube means in a first of said energizing circuits, each being in an electric circuit bypassing said output device by vacuum tube conduction to neutralize the potential in said circuit; biasing circuits for said vacuum tube means normally potentialized to maintain said first tube conducting and the other non-conducting; control means common to said biasing circuits for altering the biasing potential thereof to reverse the operating status of the respective vacuum tube means upon actuation of said control means; a second control means for the biasing circuit of said first vacuum tube means for actuation following actuation of said first-named control means to hold said first vacuum tube means non-conducting as the return to normal status of said first control means reestablishes the potential in its biasing circuit to return the second vacuum tube means to non-conducting status; the second energizing circuit being electrically in circuit with said second control means and responsive to the return to normal status thereof to impress a potential upon the output device sufficient to supplement the potential of said first energizing circuit to operate the output device.

18. An electrical network for energizing an output device only by a predetermined sequential operation of a plurality of switches, comprising a partially energizing circuit for said output device, said circuit being capable of supplying to said device an electrical potential which approaches but does not attain the threshold level of potential for actuating said device; means in said circuit and electrically in circuit with certain of said switches for depressing the potential of said circuit below said threshold approach potential when said switches are in open circuit status and for removing the last mentioned depressant effect with said certain switches in closed circuit status; means in circuit with another of said plurality of switches and connected with said depressant means to hold said means in depressant-removing condition upon closure of said second named switches in overlapping relationship with closure of said first switches and subsequent opening of one of said first switches; means in partially energizing circuit for momentarily delaying the return of said depressant means to original open circuit status upon opening of all of said switches; and electric circuit means in circuit with the last of said switches and with said output device, and responsive to the opening of said switches to place a momentary additional surge of potential in said output device sufficient to supplement said partially energizing circuit in such depressant removing condition to carry beyond the threshold value of operation potential of said output device to actuate the same.

19. A system for the control of an electric work circuit, comprising a thermionic tube in said work circuit and adapted to function as control means therein; a grid control circuit for said thermionic tube; a multiple switch unit; means

for impressing on said thermionic tube a grid bias of substantially fixed value sufficient to prevent substantial current flow in said tube upon closing a selected group of switches in said multiple switch unit; means for reducing said grid bias to a point intermediate such fixed value and a current flow permitting value upon opening certain of said group of switches after such preceding closure; and means responsive to the subsequent opening of additional switches of said group further to reduce the grid bias of said thermionic tube from such intermediate point to permit current flow therein.

20. A system for the control of an electric work circuit, comprising a thermionic tube in said work circuit; means for connecting a plurality of switches for subsequent operation to control the grid circuit of said thermionic tube; said last means including means for impressing a predetermined grid bias sufficient to prevent conduction on said thermionic tube upon the closing of at least an initial two of said switches, means for reducing the said bias from such predetermined bias to a level approaching the threshold level for conduction of said tube upon the subsequent opening of at least one of said two switches while simultaneously closing a third switch of said multiple switch unit, and means resulting from the opening of said third switch while at least one of the first-named switches remains open, to potentialize said grid from said approach level to beyond the threshold level to bring said tube to conducting status, and means responsive to said conducting status to energize said work circuit.

21. A system for controlling an electric work circuit comprising a gaseous triode functioning as a normally non-conducting element in series with the said work circuit; a grid control circuit for said triode; a plurality of electric switches; means responsive to the closing of at least an initial two of said plurality of switches to impress a high negative bias on the said grid circuit; means responsive to the subsequent opening of at least one of said switches and the simultaneous closing of a third switch to reduce the grid bias to a point approaching, but not attaining, a threshold level for conducting condition of said triode; means responsive to the opening of said third switch while keeping at least one of said first-named switches open to carry the grid bias from such approach point to beyond the threshold level; and means independent of said switches and energized by the conducting status of said triode, to restore said triode to non-conducting condition.

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