

April 29, 1952

J. L. BARKER ET AL
ELECTRONIC CIRCUIT

2,594,276

Filed Aug. 26, 1950

2 SHEETS—SHEET 1

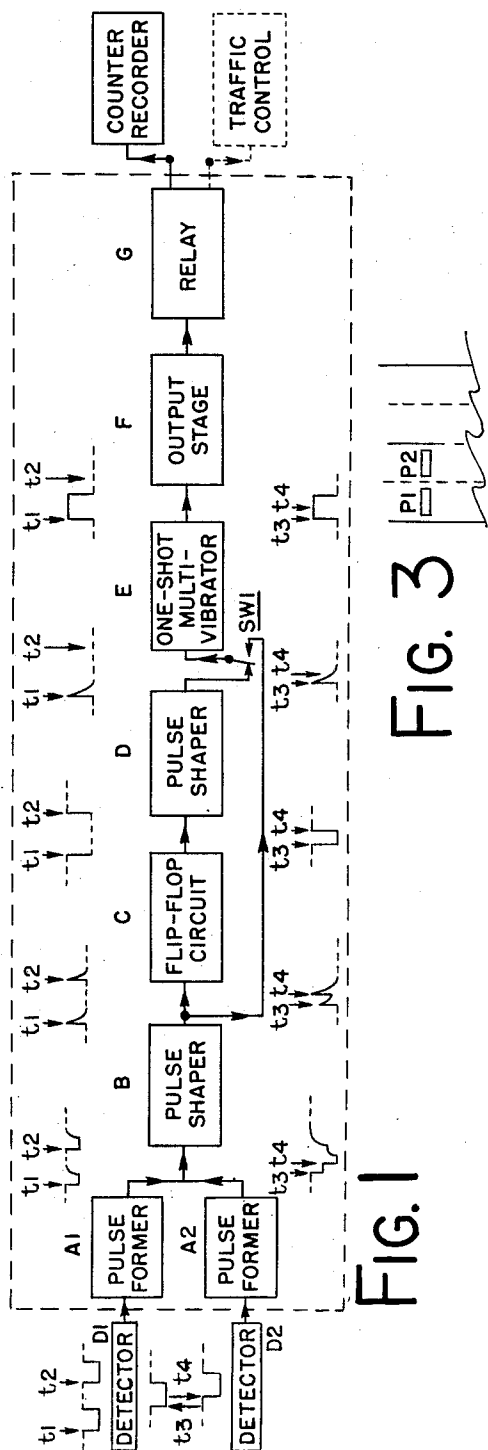


FIG. 1

FIG. 3

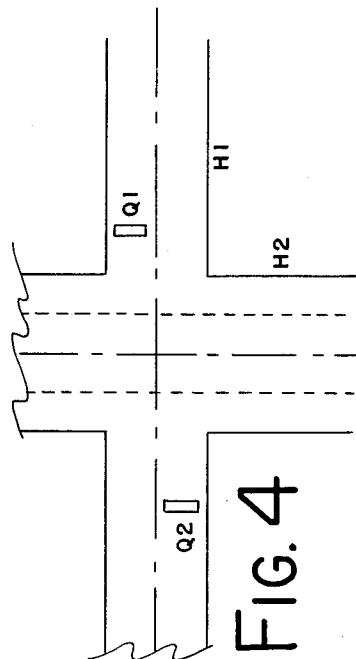


FIG. 4

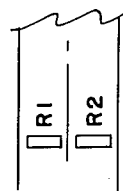


FIG. 5

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2 SHEETS—SHEET 2

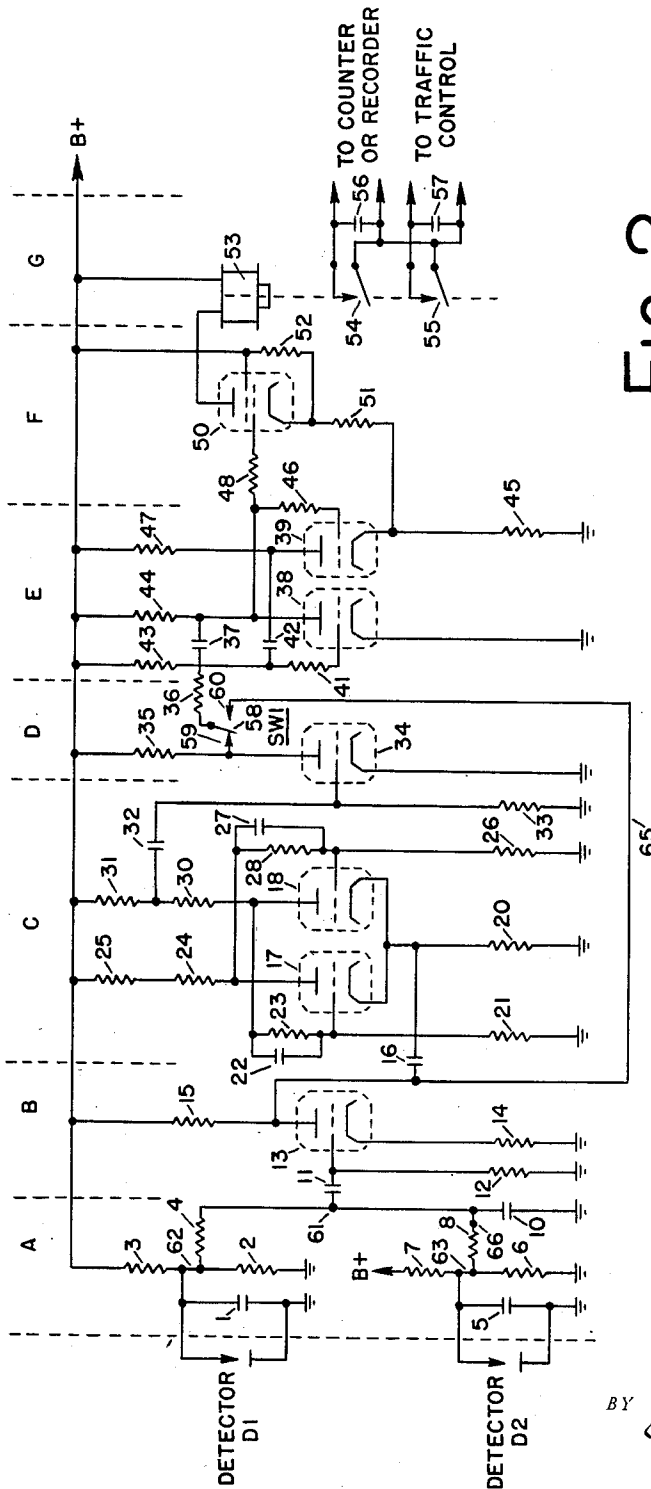


FIG. 2

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UNITED STATES PATENT OFFICE

2,594,276

ELECTRONIC CIRCUIT

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Application August 26, 1950, Serial No. 181,632

14 Claims. (Cl. 235—92)

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This invention in its more general aspects relates to an electronic circuit for responding to input pulses of relatively short but variable time length and variable time spacing or overlap to provide output pulses of substantially uniform character and in substantially predetermined numerical relation to such input pulses.

From a more particular aspect the invention relates to an improved traffic counting circuit for counting traffic actuations at a plurality of traffic detectors to respond to very short actuations and to distinguish between closely spaced or partially overlapping actuations to provide a highly accurate count of traffic over a wide range of speed and volume, but particularly at relatively high speeds and heavy traffic volumes.

This circuit is designed primarily for use in a traffic counting system in which the input pulses originate from traffic detectors which are actuated once for each axle crossing a detector and in which the output pulses actuate a counter or recorder. In one form of the invention, particularly for single detector counting, one output pulse is derived for each input pulse and one count is made for each actuation, as one count per axle for example. In another and preferred form of the invention a divider circuit is included so as to derive one output pulse for each two input pulses, thus counting every second axle or substantially one count for each vehicle in the case of predominantly two axle vehicular traffic, and enabling input pulses of closer time relationship to be distinguished.

This electrical circuit is also of significance as a high speed response circuit for supplying controlled output pulses to a traffic control or signal device or other control or indicating or counting device in response to variable actuation pulses from one or more traffic actuated switches or detector devices actuated by passing objects.

The automatic counting of roadway vehicle traffic presents problems not only in the response to very short pulses arising from high speed traffic actuations but also in distinguishing between closely spaced or overlapping pulses. If traffic is being counted in a single lane by means of a single traffic detector for example the question of overlapping pulses ordinarily does not arise, and the problem in such case is primarily one of detection of short pulses and of separation of closely spaced pulses whose time spacing is of the order of time between successive axles of any vehicle, which is the time required for a vehicle to move the distance between successive axles. At a speed of 68 miles per hour for exam-

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ple, the time spacing of such pulses is about $\frac{1}{10}$ of a second for an axle spacing of about 10 feet, and at such speed the time spacing of pulses is about .03 second for an axle spacing of about 3 feet for any given vehicle. Such time spacing between actuations on successive axles of an individual vehicle will ordinarily be considerably less than the time spacing between actuations by the rear axle of one vehicle and the front axle of the next following vehicle in the same lane.

However when it is desired to count traffic at more than one location or in more than one lane, overlapping or much closer time spacing of pulses may occur on two or more traffic detectors placed for actuation by vehicles in the respective locations or lanes.

The problem of distinguishing between closely spaced or overlapping pulses becomes much greater as the volume of traffic increases, particularly in multiple lane highways, and unless effective means are provided to distinguish between such pulses the accuracy of the counting falls quite materially as the traffic volume increases due to the rapidly increasing percentage of overlapping or very closely spaced actuations under such circumstances and the consequent loss of counts if such actuations can not be distinguished.

In analyzing this problem of counting heavy multiple lane traffic it is found that two overlapping pulses or two successive pulses spaced materially less than one-half of the time spacing between successive axles of the same vehicle, very rarely occur without a following time spacing of considerably greater length. Thus in general in two adjacent traffic lanes for example the occurrence of two actuations more closely spaced than one-half of the minimum axle spacing for a single lane will be followed ordinarily by a greater time spacing before the next succeeding actuation. In this connection it will be understood for example that if two vehicles in adjacent traffic lanes and having the same wheel base are proceeding in the same direction with one vehicle half a length ahead of the other, the time spacing of the successive actuations received from the two detector sources would be approximately one-half of the time spacing between adjacent axles of either vehicle alone. If it is now assumed however that the leading vehicle is less than one-half a length ahead of the trailing vehicle in the adjacent lane the front axle actuations will be closely spaced and the rear axle actuations will be closely spaced and such spacing will be less than the spacing be-

tween the front axle actuation of the trailing vehicle and the rear axle actuation of the leading vehicle.

On the other hand if it is assumed that the leading vehicle is more than one half a length ahead of the trailing vehicle in the adjacent lane the rear axle actuation of the leading vehicle and the front axle actuation of the trailing vehicle will be closely spaced and such spacing will be considerably less than the spacing between successive axles on the same vehicle. In each of the last two cases the more closely spaced actuations will be less than one-half of the spacing between successive axles of the same vehicle.

It will be noted that in any case the minimum time spacing between the first and third actuations of any three actuations will not be less than the time spacing between successive axles of the same vehicle.

The present invention takes advantage of this situation by employing an extremely fast response circuit which is not only able to respond to very short actuation pulses and provide longer output pulses for operation of a counter, but also provides for dividing the number of pulses to derive one output pulse for every second input pulse to enable the longer output pulse to be obtained in the longer time spacing ordinarily occurring after any pair of extremely closely spaced or overlapping pulses. Sufficiently fast counters can be obtained to respond to a pulse length of somewhat less than the time spacing between axles of the same vehicle in high speed traffic.

The present invention further provides means for distinguishing between the overlapping pulses by detecting the leading edges of such pulses and by providing a two stage response circuit such that successive leading edges of two overlapping pulses may be distinguished.

In this connection it will be appreciated that with increasing traffic volumes the number of opportunities of random actuations occurring at detectors in different traffic lanes increases, but that the possibility of two such actuations starting substantially simultaneously is so extremely small as to be negligible if a very fast response circuit is employed which is able to distinguish between the starting of overlapping pulses where the time separation between the starting of such pulses is extremely small in relation to an already small total time length of the pulse itself.

Thus a circuit in accordance with the invention employs means of this character in a novel manner to detect the leading edges of such overlapping pulses and thus to distinguish between nearly coincident or nearly simultaneous pulses to such a high degree that a very accurate count of high speed heavy volume traffic can be provided.

It is appreciated that means have been proposed in the prior art for the separation of closely spaced or overlapping pulses from traffic actuations and the like for example but such means in the prior art with which we are familiar employ relatively complex multiple channel relay circuits and in some cases multiple stage relay chains for the several channels. Such circuits are limited by the response time of the individual relays and the time sequence of operation of the successive relays as well as in the dependence upon careful adjustment of the relay contacts and operating parts.

This matter of relay adjustment is of particular significance since the operating relations of

different electromagnetic relays and relay contacts will vary considerably over a period of time under practical service conditions and relays must be readjusted frequently in closely timed relay circuits whereas electronic tube circuits of the type employed in accordance with the invention do not require such critical or frequent readjustment.

The present circuit provides a greatly improved and simplified means for counting high speed actuations from multiple sources in which the only moving parts are the output relay contacts and which will avoid the difficulties of multiple relay circuits.

It is thus a general object of this invention to provide an improved electrical translating circuit for responding to very short input pulses and distinguishing between very closely spaced input pulses to provide output pulses of substantially uniform length and of predetermined numerical relation to such input pulses.

It is also an object of the invention to provide an electrical circuit to respond to very closely spaced and partially overlapping pulses arising from two pulse sources and to distinguish between such pulses to provide output pulses of substantially uniform length and in predetermined numerical relation thereto.

It is also an object of this invention to provide a traffic counting circuit for responding to very short and closely spaced or partially overlapping traffic actuations on a plurality of traffic detectors to distinguish between the actuation pulses to provide output pulses of sufficient time length and in predetermined numerical relation to such actuation pulses so as to provide a highly accurate count of multiple lane heavy traffic.

Referring to the drawings,

Fig. 1 shows a block diagram of a preferred form of the invention.

Fig. 2 shows a schematic circuit diagram of the same preferred form of the invention as shown in Fig. 1.

Figs. 3, 4, and 5 show some of the possible arrangements of traffic detectors on a highway.

Referring now to the block diagram of Fig. 1 the translating circuit itself is shown generally within the broken line while the units associated with this circuit in its preferred use are shown outside the broken line, the detectors D1 and D2 being shown at the left at the input side of the circuit, and the counter or recorder and traffic control being shown at the right at the output side of the circuit, the circuit serving either one or both of such devices depending upon the output provisions and the desired use. It will be appreciated that in some instances it may be desired to operate only a counter or recorder while in other instances, particularly at intersections, it may be desired to make a count of the total traffic approaching as well as to operate a traffic control device or traffic signal for example.

When it is desired to obtain one output pulse for every two input pulses, for a count of two axle vehicles for example, the circuit is used with the arm of the switch SW1 to the left, as shown, connecting all the blocks together in the order in which they are lettered.

The waveforms of pulses at several points in the circuit are shown in this figure, the waveform sketches in the upper part of the figure showing the situation with two input pulses t_1 and t_2 considerably separated in time, as in the case of two successive axles of a vehicle for example, and the waveform sketches below showing the situa-

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tion with two input pulses t_3 and t_4 overlapping and with the leading edge of t_4 lagging very slightly behind the leading edge of t_3 , as in the case of nearly simultaneous actuations by axes of vehicles in adjacent lanes for example. The pulses shown to the left at the detectors represent four input pulses corresponding with actuations occurring at different times t_1 and t_2 on detector D1 and at times t_3 on detector D1 and t_4 on detector D2.

The input pulse in the form of a circuit closing or shorting action, which may be due to a traffic detector as shown, is applied to the input terminals of either one of the pulse formers A1 or A2 shown. A substantially square negative pulse is formed and is changed to a sharp positive spike by the pulse shaper B which responds only to negative pulses.

This positive spike is derived from the leading edge of the negative pulse from the pulse former A1 and therefore is independent of the length of the negative pulse and also allows the circuit to respond to another closely following input shorting action and resulting negative pulse from the other pulse former A2. The positive pulse trips the flip-flop circuit from one of its stable conditions to the other, delivering either a positive or a negative pulse, depending upon the direction in which the flip-flop circuit has been triggered, to the pulse shaper D which follows. This pulse shaper reacts only to a negative pulse and thus only to every alternate shorting action at the input terminals of the circuit. This pulse shaper D delivers a sharp positive pulse through the switch SW1 to the one shot multivibrator E, causing it to cycle, as will be explained later in connection with Fig. 2, and to deliver a square positive pulse to the output tube F. This causes the output tube to conduct heavily for the duration of this output pulse, thus operating the relay G to close its contacts so as to operate the counter or recorder or the traffic control apparatus as indicated.

Since the pulse shaper D reacts only to the negative pulses from the flip-flop circuit it delivers only one positive triggering pulse to the one-shot multivibrator E for every two detector actuations. Thus the circuit delivers one output pulse for every two input pulses and this halving action is due to the flip-flop circuit C and the pulse shaper D.

If it is desired to have one output pulse for each input pulse, in the case of non-overlapping or more widely spaced pulses, the switch SW1 is reversed so that the output of the pulse shaper B is applied through the switch to the one-shot multivibrator E, and the output of the flip-flop circuit C and pulse shaper D is not used.

Thus it will be observed that the flip-flop circuit and following pulse shaper serve as a form of divider circuit when used. It will be appreciated that one or more additional flip-flop circuit and pulse shaper combinations might be inserted between the pulse shaper D and the one-shot multivibrator E in order to further subdivide the number of pulses, or any other suitable divider circuits, such as ring counter circuits or applicable frequency divider circuits, may be inserted in order to obtain a single output pulse for any predetermined number of input pulses.

It will also be appreciated that additional detectors and associated pulse formers may be used, with additional dividing circuits, and that two circuits as in Fig. 1 may be employed for four detectors with the circuit outputs combined in the

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input of a third such circuit in place of detectors at the input of the third circuit to serve four lanes if desired.

Referring now to the schematic diagram of Fig. 2 the operation of the circuit will be explained.

When no detector actuations are present the condensers 1 and 5 in the two pulse formers charge to a voltage equal to that across the resistors 2 and 6 respectively. The resistors 2 and 5 are of equal size and the resistors 3 and 7 are of equal size but much larger than 2 and 6. The result is that the two condensers 1 and 5 are each charged to substantially the same small positive voltage dependent upon the ratio of resistances 2 and 6 to 3 and 7, say for example 15 volts. Since the leads 62 and 63 are at the same potential there will be no current flowing through resistors 4 and 8 and junction 61 between the two resistors will be at the same potential, 15 volts in the example.

Actuation of detector D1 shorts condenser 1 causing the potential at lead 62 to drop suddenly from some positive value to zero, thus comprising essentially a negative pulse with a sharp leading edge approximating that of a square wave. There now exists a potential difference between leads 62 and 63 since 63 is still at the positive potential, 15 volts in the example. A current flows through equal resistors 4 and 8, and the junction 61 suddenly assumes a potential half as great as before. Following the example this is a drop of 7.5 volts. This change is applied to the differentiating network consisting of condenser 11 and resistor 12. The condenser 11 must change its charge by a like amount and the charging current produces a negative spike of voltage across resistor 12 and on the grid of the pulse shaper tube 13 and corresponding in time to the sudden potential change at point 61. This produces a positive spike at the plate of tube 13 which is used to trigger the flip-flop circuit C and is also sent over lead 65 to contact 60 of switch SW1. The shunting effect of resistors 4 and 8 when detector D1 is actuated does not materially change the potential at lead 63 because these resistors 4 and 8 are considerably larger than the resistor 6.

Condenser 1 is large enough so that a very short interruption of the detector closure, such as by bouncing or chattering of the detector contact plate for example, will not result in an additional impulse because the condenser will not charge sufficiently in the short interruption to produce a sufficiently large negative pulse when the contacts reclose. Any very small short voltage changes at junction 61 are shunted around the differentiating circuit by condenser 10 which is very small so that it will accomplish this purpose without shunting the desirable pulses. Another purpose of the large condenser 1 is to provide capacitance across the detector leads which is considerably larger than the capacitance of the leads themselves so that any variations of the lead capacitance will not materially affect the operation of the circuit.

Actuation of detector D2 instead of detector D1 produces the same result at junction 61 as described above, the description of the action being identical except that elements 5, 6, 7, 8 and 63 respectively are employed in place of elements 1, 2, 3, 4 and 62.

After a detector is actuated, shorting one of the respective condensers 1 or 5, and the detector is released, this allows the condenser to recharge through one of the respective resistors 3 or 7. As

mentioned above, these components are large enough so that no appreciable charge will be acquired by the condenser 1 or 5 during a very short interruption of detector closure. However, these components are small enough so that a sufficient charge for a usable pulse will be acquired in the time between actuations by the successive wheels of a rapidly moving vehicle. As the condenser voltage rises toward its fully charged value, 15 volts in the example above, the potential at junction 61 remains substantially halfway between the potentials at leads 62 and 63. The time constant of the differentiating circuit 11 and 12 is short enough so that the charge on condenser 11 will follow closely the rise in potential at point 61 and very little change will be felt at the grid of tube 13.

This time constant is further shortened in effect by the clipping action of the parallel path of the grid-cathode circuit of tube 13 for positive grid voltage, and the resistance 14 is small enough to be neglected. This prevents response to any appreciable stray positive pulse.

The two detectors for use with this circuit may be placed in any of a variety of situations, three of which are shown in Figs. 3, 4, and 5 by the pairs of detectors P1 and P2, Q1 and Q2, and R1 and R2.

An arrangement of this sort may be used for counting all the traffic traveling in one direction on a four lane highway in which case one detector would be employed in each of the two lanes used for travel in the direction in question. Another use for an arrangement of this sort may be to count all the traffic on a two lane highway approaching an intersection from both directions in which case one detector would be placed in each approach lane so that traffic in the lane would cross the detector shortly before reaching the intersection. A further use for an arrangement of this sort may be to count all the traffic using a two lane highway in which case the detectors would be placed one in each lane adjacent to each other. These examples obviously do not cover all the cases but indicate the possibilities.

In each of these cases it is possible to have vehicles passing over the two detectors of a pair almost simultaneously. In the event that one detector should be actuated while the other detector is in the actuated condition a second pulse will be felt in the following circuit as described below. If detector D1 only is in the actuated condition lead 62 is at ground potential, lead 63 is at its maximum potential of 15 volts in the above example and point 61 is at a potential approximately midway between the potentials at leads 62 and 63, about 7.5 volts in the above example.

At the start of the assumed actuation of detector D1 a 7.5 volt drop was felt at point 61 and while condenser 11 changed its charge by this amount a negative 7.5 volt spike appeared on the grid of tube 13 resulting in a similarly shaped but amplified positive spike on the plate of tube 13. This positive spike is applied to the cathodes of tubes 17 and 18 of the flip-flop circuit through the differentiating network consisting of condenser 16 and resistor 20. These components 16 and 20 are small enough to provide a short time constant so that the pulse applied to the cathodes of tubes 17 and 18 is of much shorter duration than the pulse at the plate of tube 13.

Actuation of detector D2 shorts condenser 5 and causes the potential at lead 63 to drop suddenly from its positive value to ground potential.

If detector D1 is also in an actuated condition when this occurs then both leads 62 and 63 are at ground potential and the potential at point 61 drops from its intermediate value, 7.5 volts in the above example, to ground potential. This will be the case no matter how closely the two detectors are actuated. If the actuations start far enough apart however there will be essentially two completely separate spikes on the grid of tube 13. If the second actuation starts before condenser 11 has finished its change of charge as a result of the first actuation then the second spike will be superimposed on the first. The second spike will be its normal height but with its base at the potential existing due to the first actuation at the moment of the second actuation. This is illustrated in the lower wave form sketches in Fig. 1.

In the rare case that the two actuations occur simultaneously the two spikes will appear as one of twice the height, 15 volts in the above example, and thus will not be separately distinguished, but if the actuations start an extremely short time apart the two spikes will appear as a somewhat broader pulse with two peaks and may thus be separately distinguished by the fast acting flip-flop circuit.

Whatever the shape of the negative pulse on the grid of tube 13 it will produce a similarly shaped amplified positive pulse on the plate. Due to the shorter time constant in the charging circuit for condenser 16 as explained above a double positive pulse on the plate of tube 13 will appear as two substantially separate positive spikes on the cathodes of tubes 17 and 18 provided that the leading edges of the two positive pulses are separated enough to allow a fair amount of charge of capacitor 16. Separation of two pulses with spacing of leading edges of the order of $\frac{1}{500,000}$ of a second may be achieved.

The flip-flop circuit consists of tubes 17 and 18 and their associated circuits. The arrangement is such that only one of the tubes 17 and 18 conducts at any one time. There are two stable states, one with tube 17 conducting and the other with tube 18 conducting. An outside signal must be injected in order to trigger the flip-flop circuit from one stable state to the other. If tube 18 is conducting and tube 17 is non-conducting then the plate of tube 17 is at nearly the same potential as the positive supply voltage B+, which may be 100 volts for example, but the plate of tube 18 is at a considerably lower potential due to the plate current flowing through resistors 30 and 31. The grid of tube 18 is connected to the junction of the voltage divider consisting of resistors 26 and 28 across which the voltage at the plate of tube 17 is applied. The grid of tube 17 is connected to the junction of the similar voltage divider consisting of resistors 21 and 23 across which the voltage at the plate of tube 18 is applied.

These voltage dividers are arranged so that the potential at the grid of each tube is about one third as great as the potential at the plate of the opposite tube. Since the plate of tube 18 is at a considerably lower potential than the plate of tube 17, the grid of tube 17 is at a correspondingly lower potential than the grid of tube 18. The cathodes of the two tubes are tied together and are considerably above ground potential due to the tube current through resistor 20. With proper circuit design the grid of tube 17 is at a low enough potential so that tube 17 is cut off.

The positive pulses from pulse shaper 13 are

applied to the cathodes of the two tubes of the flip-flop circuit. The increase in cathode potential increases the grid bias on tube 13 and cuts this tube off. This allows the plate of tube 13 suddenly to rise nearly to the B+ potential. This sudden rise is applied through condenser 22 directly to the grid of tube 17 causing this tube to conduct since the grid goes farther positive than the cathode has gone. The plate potential on tube 17 will drop so as to decrease the grid potential of tube 13 and insure that tube 13 will remain cut off, the cathodes remaining at a positive potential due to the current through tube 17. A subsequent positive triggering pulse at the cathodes, due to another detector actuation, will affect the flip-flop circuit C in a reverse manner, cutting off tube 17 and again allowing tube 13 to conduct. The charging times of condensers 22 and 27 are small enough so that after each triggering the grids will be able to recover from their transient conditions before the next pulse.

The square wave output of the flip-flop circuit is taken from the plate circuit of tube 13 between resistors 30 and 31 and applied to the differentiating circuit consisting of condenser 32 and resistor 33, which applies alternate positive and negative spikes to the grid of the pulse shaper tube 34.

Since there is no bias on tube 34 the positive spikes are clipped by the diode action of the grid-cathode circuit and such spikes have little or no effect. However, the negative pulse, which is applied to tube 34 every time tube 13 starts to conduct and therefore every second time a detector is actuated, causes the conduction of tube 34 to decrease materially or even to stop while the spike is applied. This results in a sharp positive spike at the plate of tube 34 and at contact 59 of switch SW1.

As previously described the positive spikes at the plate of tube 13 of pulse shaper B are transmitted by lead 65 to contact 60 of switch SW1. Thus there is available at contact 60 a positive spike for each detector actuation and at contact 59 a similar positive spike for every alternate detector actuation. These positive spikes are sufficient for triggering the one-shot multivibrator E and according to whether the arm 58 of switch SW1 is to the left or to the right the multivibrator will be triggered once for every other detector actuation or once for each detector actuation.

The one shot multivibrator consists of tubes 38 and 39 and their associated circuits. It has only one stable state, the condition with tube 38 conducting and tube 39 cut off. This one stable state is assured by positive return of the grid of tube 38 and by the bias on tube 39 due to the voltage divider consisting of resistors 45, 51, and 52.

The grid of tube 39 also has a positive return through the plate resistor of tube 38 but there is no trouble here because the plate current of tube 38 keeps the plate potential low and thereby allows the grid of tube 39 to stay well below its cathode potential.

The positive spike from the plate of tube 34 or from the plate of tube 13 is transmitted through switch SW1, resistor 36, and coupling condenser 37 to the plate of tube 38 and the grid of tube 39. Resistor 36 is used to minimize loading of tube 38 by the previous circuit. The positive pulse on the grid of tube 39 causes the tube to conduct so that its plate potential drops

sharply. This drop is transmitted through condenser 42 to the grid of tube 38 causing it to be cut off and allowing its plate to rise in potential so as to maintain this higher potential after the triggering spike from tube 34 stops. This condition continues until the condenser 42 has time to recharge sufficiently to allow the grid of tube 38 to rise in potential enough so that tube 38 will start to conduct. This causes its plate potential to fall, decreasing the grid potential of tube 39 and thereby decreasing the conduction of tube 39 so that the plate potential of tube 39 will rise. This rise is immediately transmitted through condenser 42 to increase the rate of conduction of tube 38 and so quickly return the one shot multivibrator to its stable state.

The potential at the plate of tube 38 is applied not only to the grid of tube 39 but also to the grid of output tube 50. This tube is heavily biased by connection of its cathode to the voltage divider consisting of resistors 45, 51 and 52 so that it does not conduct when the one shot multivibrator E is in its stable state. However, when the one shot multivibrator is triggered the plate of tube 38 rises in potential so that the grid of tube 50 also rises and tube 50 conducts heavily enough to energize relay 53, closing contacts 54 and 55. Leads from these contacts provide output terminals. Contacts 54 may be connected appropriately into a counter or recorder circuit so as to actuate the counter. Contacts 55 may be connected into a traffic control circuit if desired so as to actuate the latter. The length of time that the contacts are held closed is dependent upon the length of time that the one shot multivibrator remains in the unstable condition with tube 38 cut off. This is primarily dependent upon the rate at which condenser 42 is recharged and is designed to be long enough to properly actuate a counter.

A feature of this invention is the interconnection between the relay circuit and the one shot multivibrator circuit through the common cathode resistor 45. This is to compensate for changing characteristics of tube 50 due to aging or replacement and for variations in B+ voltage supply. Current will flow in tube 50 during the entire time that the one shot multivibrator is in its alternate state with tube 38 cut off. The relay 53 will start to close its contacts as soon as current starts to flow, the time taken for this closing action being greater for a smaller current than for a larger current, and will release its contacts upon cut off of tube 50, dependent on the magnitude of the current that is flowing through the relay coil. Thus if the one shot multivibrator cycle were of fixed length the length of the output pulse due to closure of contacts 54 would be greater for greater relay current. However the length of the multivibrator cycle is partially dependent upon the cathode potential of tube 39. If the cathode potential is relatively low then the cycle is relatively long since the initial drop in anode potential of tube 39 is relatively large and thus condenser 42 must charge a relatively large amount before tube 38 again breaks into conduction ending the multivibrator cycle. If the cathode potential is higher the initial drop in anode potential of tube 39 is smaller and condenser 42 does not have to charge so much to allow tube 38 to conduct so the cycle is shorter. Thus a large current through tube 50 and relay 53 causes the relay contacts 54 and 55 to close more rapidly but also, in flowing through the common cathode resistor 45, causes

the cathode of tube 39 to assume a higher potential thereby causing the one shot multivibrator to cycle more rapidly. The effect of the interconnection is to tend to maintain the time of closure of the relay contacts 54 and 55 constant despite variations in the characteristics of tube 50 and B+ voltage.

This circuit may be used with only one detector if desired. The second detector alone may be omitted or the detector and associated pulse former A2 comprising capacitor 5 and resistors 6, 7 and 8 may be disconnected at point 66.

The term pulse is used here not only in its more usual sense of a momentary appearance of electrical voltage or current or change of such from one level to another and return, such as a half wave which may be of a wide variety of wave forms, for example, but is also used in a broader sense of a change of electrical condition in a circuit from an initial or normal condition to a different condition and return to the initial condition substantially, as by the closing of the contacts of one of the detectors D1 or D2 for a brief time period for example. As applied to the closing of the detector contacts for example by traffic actuation it will be appreciated that the pulse representing such contact operation would be in a sense a square wave pulse on the basis that the contacts would be normally opened and then shift substantially instantly to the closed condition upon actuation for example remaining in this closed condition as long as the actuation continues and then returning to the normal condition substantially instantly upon release of the actuation. Thus this effect may be represented by a substantially square wave pulse considered as an input pulse representing the circuit closed condition with the length of the pulse corresponding to the length of the actuation substantially of the circuit closer. The apparatus within the enclosed broken line in Fig. 1 for example may be considered as a circuit having an input side at the left for receiving input pulses corresponding to the closure times of one or more detectors D1 and D2 for example and having an output side at the right for providing controlled output impulses in response to such input pulses and having a predetermined numerical relation thereto.

The detector D1 or D2 is represented in the circuit diagram of Fig. 2 as a circuit closer or switch and is employed in the form in which the contacts are closed in response to actuation and opened upon release of actuation. Various forms of traffic actuated switches or detectors are well-known in the art. The detector may take the form of a pair of contact plates for example one over the other which are brought together by the pressure of a vehicle wheel and released by resilience of one of the plates or of other restoring means at the edges of the plates for example. However it will be appreciated that the contacts designated detector D1 or detector D2 may be of other forms for actuation by traffic or other desired actuating element whose actuation it is desired to count or record or employ for control purposes.

The circuit of the invention is designed primarily for counting vehicular traffic and in such application a counter or register device is connected to the output of the circuit. In such application of the invention it is ordinarily preferred to have an automatic record of the count made at periodic intervals and a counter

of the printing type is thus ordinarily used although it will be appreciated that the invention is not limited to this type but other forms of recorder or counter or traffic control device or other device which may employ a number of traffic actuated pulses in which it is desired to respond as far as possible to individual pulses even though the actuations may be very closely spaced or partially overlap.

Although a preferred form of the invention has been shown and described and certain alternate forms and variations have been illustrated or described it will be appreciated by those skilled in the art that various other changes may be made in the parts or arrangement of the combination without departing from the spirit of the invention.

We claim:

1. An electrical circuit for providing controlled output pulses in response to input pulses varying in time relation including in combination a plurality of input pulse receiving circuits, a pulse former circuit individual to each input pulse receiving circuit for forming a substantially square wave front pulse in response to each input pulse, a pulse shaper circuit connected to receive the outputs of the several pulse former circuits to provide a very short spike shaped pulse in response to the square wave front of the pulse output of said pulse former circuits, a divider circuit controlled by said pulse shaper to derive one short output pulse for a larger predetermined number of pulses from said pulse shaper, and means including a one shot multivibrator circuit controlled by the output of said divider circuit to provide output pulses of substantially uniform character in response thereto.

2. An electrical circuit for providing controlled output pulses of predetermined numerical relationship in response to input pulses varying in time length and time relation including in combination, input pulse receiving circuit means, a pulse shaper circuit controlled by said pulse receiving circuit means, a flip-flop circuit having two stages of operation and connected to be controlled by said pulse shaper circuit to be operated to alternate stages by successive input pulses, a second pulse shaper circuit controlled by said flip-flop circuit to provide a shaped pulse in response to one stage of operation of said flip-flop circuit, and means including a one shot multivibrator circuit controlled by said second pulse shaper circuit to provide controlled output pulses in response to the pulses derived from said second pulse shaper circuit.

3. An electrical translating circuit including in combination a plurality of input terminals for connection of a plurality of individual circuit controlling devices adapted to be actuated for varying time periods and time spacing with the possibility of varying degrees of overlap of such actuation periods, a plurality of pulse formers including one individual to each set of input terminals to provide first output pulses corresponding to the individual actuation periods, a pulse shaper for differentiating such first output pulses to provide spiked output pulses of short time length as compared to such first output pulses and in response thereto, a divider circuit controlled by said pulse shaper to derive one spiked output pulse for a larger predetermined number of pulses from said pulse shaper, a one shot multivibrator connected to be triggered by such spiked output pulses to provide controlled output pulses of substantially uniform

time length in response thereto and means including output terminals for connection of an external device to be controlled by such controlled output pulses in response to such actuations.

4. An electrical translating circuit including in combination a plurality of input terminals for connection of a plurality of individual circuit controlling devices adapted to be actuated for varying time periods and time spacing with the possibility of varying degrees of overlap of such varying time periods, a plurality of pulse formers including one individual to each of said input terminals to provide first output pulses corresponding to the individual actuation periods, circuit means connecting said pulse formers in voltage divider relationship to provide a voltage of predetermined level for such output pulses in response to actuation of one only of said input circuit controlling devices and to provide a second voltage level for such output pulse in response to concurrent actuation of both of said input controlling devices whereby partially overlapping actuations will provide two pulses at different voltage levels from said pulse formers, a pulse shaper for differentiating such first output pulses to provide spiked output pulses of short time length as compared to such first output pulses and in response thereto at the two voltage levels whereby two spiked output pulses are provided in response to partially overlapping first output pulses, a divider circuit controlled by said pulse shaper to derive one spiked output pulse for a larger predetermined number of pulses from said pulse shaper, a one shot multi-vibrator connected to be triggered by such spiked output pulses to provide controlled output pulses of substantially uniform time length in response thereto, and means including output terminals for connection of an external device to be controlled by such controlled output pulses in response to such actuations.

5. An electrical translating circuit including in combination input terminals for connection of a circuit controlling means adapted to be actuated for time periods of variable length and spacing or overlap, pulse former means connected to said input terminals to provide first output pulses of character corresponding substantially to such actuation periods, pulse shaper means for differentiating such first output pulses to provide spiked output pulses in response to and of relatively short time length as compared to such first output pulses, a flip-flop circuit controlled by such first pulse output from said pulse shaper means to be triggered by each pulse thereof, and a second pulse shaper means for differentiating the pulse output of said flip-flop circuit in response to triggering of the latter from only one of its two conditions to the other to provide a spiked output pulse for every second pulse input, and one shot multivibrator means controlled by such last named spiked pulses to provide controlled output pulses of substantially uniform time length in response to and of relatively long time length as compared to such spiked pulses said second pulse shaper means having its output connected to the input of said one shot multi-vibrator to trigger the latter for each spiked output pulse of said second shaper means.

6. An electrical circuit for providing controlled output pulses in response to input pulses varying in time relation including in combination an input resistance-capacity circuit for providing a

substantially square wave pulse in response to an input pulse of varying character, a pulse shaping circuit including an amplifier tube and resistance and capacity elements to provide a sharply spiked pulse output from said resistance capacity input circuit, a flip-flop circuit having its input connected to the output of said pulse shaper circuit and including two electronic tubes interconnected in toggle relationship to provide alternate stable states of operation in response to successive input pulses, a second pulse shaper circuit connected to the output of one of the tubes of said flip-flop circuit, a trigger circuit having its input connected to the output of said second pulse shaper circuit and having two electronic tubes interconnected in biased toggle relationship to maintain the first of said tubes normally conducting and the second of said tubes non-conducting and reversible by a pulse in its input to render its first tube non-conducting and second tube conducting, said trigger circuit including a resistance capacity circuit interconnecting the tubes so as to return the trigger circuit to its initial condition within a predetermined time interval controlled by its circuit constants, and an output circuit from said last named trigger circuit to provide an output pulse only when said trigger circuit is in its second condition.

7. An electrical circuit for providing controlled output pulses in response to input pulses varying in time relation including in combination an input resistor capacitor circuit comprising two resistors in series across a source of direct voltage one side of which may be grounded, the two resistors being so proportioned as to provide a convenient potential at their junction, a capacitor from ground to said junction with shorting means operable across said capacitor so that operation of said shorting means will cause a sudden change in potential of said junction from its previous potential to ground potential, thus providing a substantially square wave pulse in response to an input shorting action of varying character, a charging circuit for said capacitor operable when said shorting means is open and having a charging time great enough so that said capacitor will not charge enough during a momentary opening of said shorting means to provide a sufficient pulse upon the reclosure of said shorting means but will provide a sufficient pulse on closure after larger openings, a pulse shaping circuit including an amplifier tube and resistance and capacity elements to provide a sharply spiked pulse output from said resistance capacity input circuit, a flip-flop circuit having its input connected to the output of said pulse shaper circuit and including two electronic tubes interconnected in toggle relationship to provide alternate stable states of operation in response to successive input pulses, a second pulse shaper circuit connected to the output of one of the tubes of said flip-flop circuit, a trigger circuit having its input connected to the output of said second pulse shaper circuit and having two electronic tubes interconnected in biased toggle relationship to maintain the first of said tubes normally conducting and the second of said tubes non-conducting and reversible by a pulse in its input to render its first tube non-conducting and second tube conducting, said trigger circuit including a resistance capacity circuit interconnecting the tubes so as to return the trigger circuit to its initial condition within a predetermined time interval controlled by its circuit con-

stants, and an output circuit from said last named trigger circuit to provide an output pulse only when said trigger circuit is in its second condition.

8. An electrical circuit for providing controlled output pulses in response to input pulses varying in time relation including in combination two similar resistor-capacitor input circuits, each comprising two resistors in series across a source of direct voltage one side of which is grounded, the resistors being so proportioned as to provide a convenient potential at their junction, substantially the same in each of said input circuits, a capacitor from ground to the junction with shorting means operable across said capacitor so that operation of said shorting means will cause a sudden change in potential of said junction from its previous potential to ground potential, the two input circuits being connected at the above mentioned junctions by means of two substantially equal resistors such that the junction of the two last named resistors will maintain a potential midway between the potentials at the two previously mentioned junctions and will therefore upon shorting action at one only of the input circuits drop suddenly from its first potential halfway to ground potential and upon shorting action at the other input circuit in addition to that at the one input circuit will drop suddenly from said halfway potential to ground potential, thus providing a substantially square wave pulse in response to a shorting action at either one of the input circuits and, in response to a subsequent nearly coincident shorting action at the other input circuit, providing a second substantially square wave pulse superimposed on the first, a pulse shaping circuit connected to said junction of said two resistors connecting said input circuits and including an amplifier tube and resistance and capacity elements to provide a sharply spiked pulse output from said resistance capacity input circuit, a flip-flop circuit having its input connected to the output of said pulse shaper circuit and including two electronic tubes interconnected in toggle relationship to provide alternate stable states of operation in response to successive input pulses, a second pulse shaper circuit connected to the output of one of the tubes of said flip-flop circuit, a trigger circuit having its input connected to the output of said second pulse shaper circuit and having two electronic tubes interconnected in biased toggle relationship to maintain the first of said tubes normally conducting and the second of said tubes non-conducting and reversible by a pulse in its input to render its first tube non-conducting and second tube conducting, said trigger circuit including a resistance capacity circuit interconnecting the tubes so as to return the trigger circuit to its initial condition within a predetermined time interval controlled by its circuit constants, and an output circuit from said last named trigger circuit to provide an output pulse only when said trigger circuit is in its second condition.

9. An electrical circuit for providing controlled output pulses in response to input pulses varying in time relation including in combination an input resistor capacitor circuit for providing a substantially square wave pulse in response to an input pulse of varying character, a pulse shaping circuit including a resistor capacitor differentiating circuit and an amplifier tube, with a grid current limiting resistor in its cathode circuit to derive a sharply spiked pulse output

from the leading edge only of said substantially square wave pulse from said resistor capacitor input circuit, a flip-flop circuit having its input connected to the output of said pulse shaper circuit and including two electronic tubes interconnected in toggle relationship to provide alternate stable states of operation in response to successive input pulses, a second pulse shaper circuit connected to the output of one of the tubes of said flip-flop circuit, a trigger circuit having its input connected to the output of said second pulse shaper circuit and having two electronic tubes interconnected in biased toggle relationship to maintain the first of said tubes normally conducting and the second of said tubes non-conducting and reversible by a pulse in its input to render its first tube non-conducting and second tube conducting, said trigger circuit including a resistance capacity circuit interconnecting the tubes so as to return the trigger circuit to its initial condition within a predetermined time interval controlled by its circuit constants, and an output circuit from said last named trigger circuit to provide an output pulse only when said trigger circuit is in its second condition.

10. An electrical circuit for providing controlled output pulses in response to input pulses varying in time relation including in combination an input resistance-capacity circuit for providing a substantially square wave pulse in response to an input pulse of varying character, a pulse shaping circuit including an amplifier tube and resistance and capacity elements to provide a sharply spiked pulse output from said resistance capacity input circuit, a flip-flop circuit having its input connected to the output of said pulse shaper circuit and including two electronic tubes interconnected in toggle relationship to provide alternate stable states of operation in response to successive input pulses, a second pulse shaper circuit connected to the output of one of the tubes of said flip-flop circuit, a trigger circuit having its input connected to the output of said second pulse shaper circuit and having two electronic tubes interconnected in biased toggle relationship to maintain the first of said tubes normally conducting and the second of said tubes non-conducting and reversible by a pulse in its input to render its first tube non-conducting and second tube conducting, said trigger circuit including a resistance capacity circuit interconnecting the tubes so as to return the trigger circuit to its initial condition within a predetermined time interval controlled by its circuit constants and by the bias on said normally non-conducting second tube, and an output circuit from said last named trigger circuit to provide an output pulse only when said trigger circuit is in its second condition, said output circuit comprising a power amplifier tube driven by said last named trigger circuit and a relay energized by the anode current of said power amplifier tube driven by said last named trigger circuit with a cathode resistor common to the circuits of said power amplifier and said second tube of said last named trigger circuit, whereby increased relay current will increase the bias on said trigger circuit tube and decrease the time of relay current flow, allowing the relay contacts to close for substantially the same period despite variations in said power amplifier tube.

11. A traffic counting circuit including a plurality of traffic actuated switch means for actuation individually by traffic, input circuits connected to such traffic actuated switch means to

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provide input pulses in response to actuations of said switch means, said input pulses being of variable time length and time spacing or time overlap in accordance with random traffic actuation of the respective switch means, and pulse shaping means for deriving very short pulses in response to one end only of the input pulses received from the several input circuits to discriminate between overlapping pulses, a divider circuit controlled by said pulse shaper to derive one short output pulse for a larger predetermined number of pulses from said pulse shaper, means including a one-shot trigger circuit controlled by the pulses provided by said last named means to provide controlled output pulses of substantial length and substantially uniform character in response thereto, and a counting device connected to be controlled by said output pulses.

12. An electrical circuit as in claim 2 in which said final means includes a power amplifier tube connected to the output of said one-shot multivibrator circuit to be driven by the output pulses therefrom and a relay connected to said amplifier tube to be energized by the anode current thereof as driven by said one-shot multivibrator, the connection of said amplifier tube to said one-shot multivibrator including a circuit having a cathode resistor common to the circuits of said amplifier tube and of said one-shot multivibrator and polarized with respect to the same to reduce the time length of the pulse of said multivibrator and the consequent time of operation of said amplifier tube and relay in response to increased relay current whereby any increase in value of relay current will tend to decrease the time of relay current flow to allow the relay to operate for substantially the same period despite variations in said power amplifier tube characteristics.

13. A counting circuit including switch means

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subject to actuation for time periods varying widely in time length and time relations, input circuit means connected to said switch means to provide input pulses of varying time length and time relation in response to such varying periods of actuation of said switch means, pulse shaper circuit means controlled by said input circuit means, a flip-flop circuit having two stages of operation and connected to be controlled by said pulse shaper circuit means to be operated to alternate stages by successive input pulses, second pulse shaper circuit controlled by said flip-flop circuit to provide a shaped pulse in response to one stage of operation of said flip-flop circuit, means including a one-shot multivibrator circuit controlled by said second pulse shaper circuit to provide controlled substantially uniform output pulses in response to the pulses derived from said second pulse shaper circuit, and a counter connected to the output of said last named multi-vibrator circuit means to be operated by said substantially uniform output pulses.

14. A counting circuit as in claim 13 in which said switch means is traffic actuated.

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