

Jan. 17, 1956

L. R. HARPER
ELECTRONIC COUNTER

2,731,201

Filed Dec. 21, 1950

2 Sheets-Sheet 1

FIG. 1

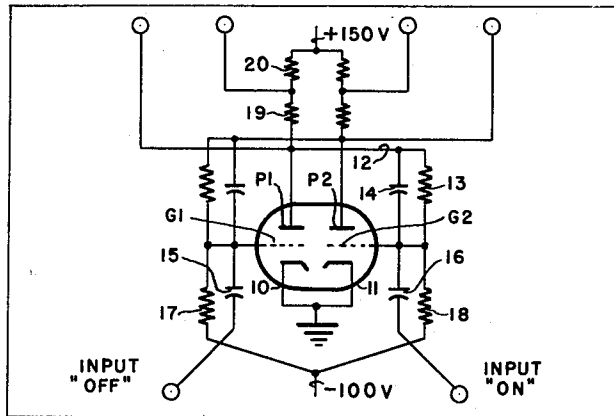


FIG. 2

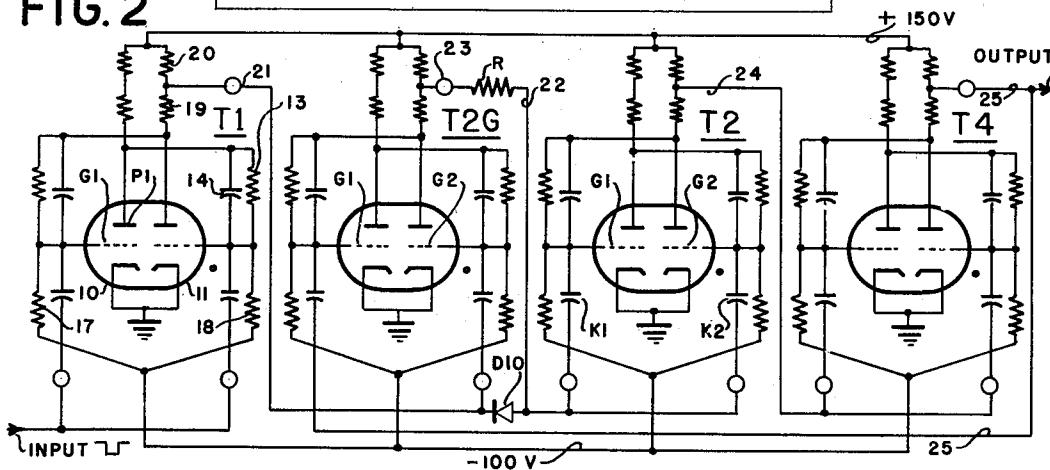


FIG. 3

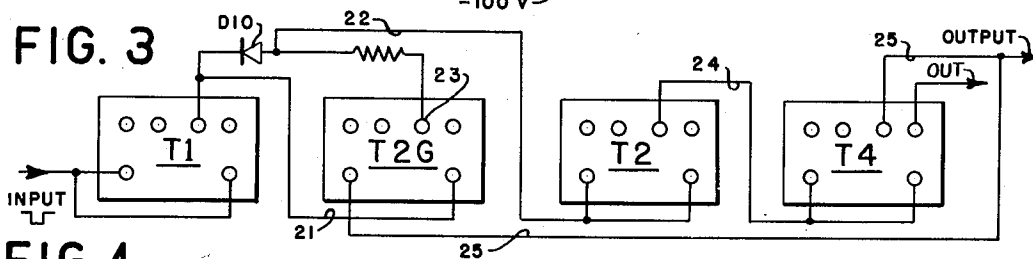
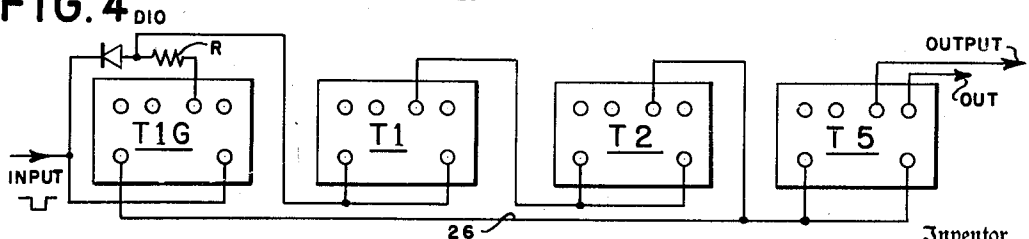


FIG. 4



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FIG. 5

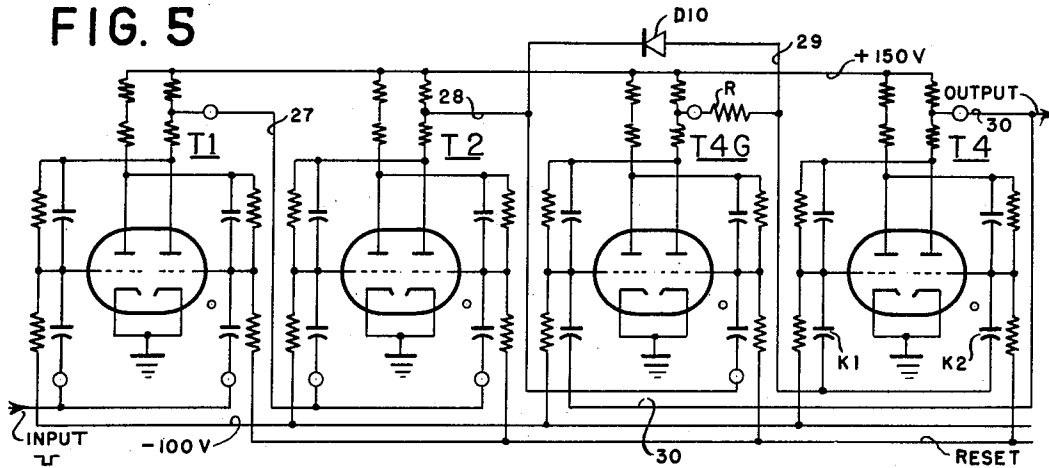


FIG. 6

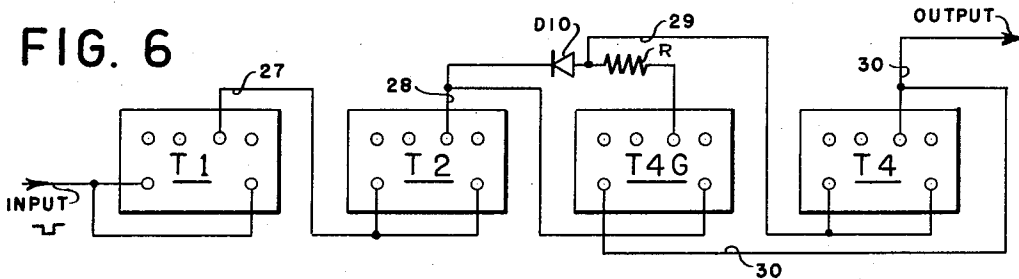


FIG. 7

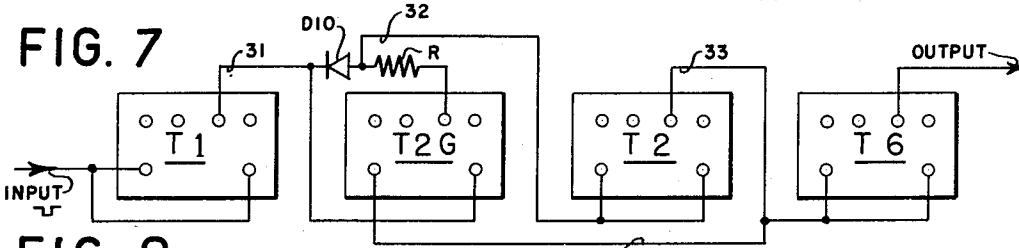
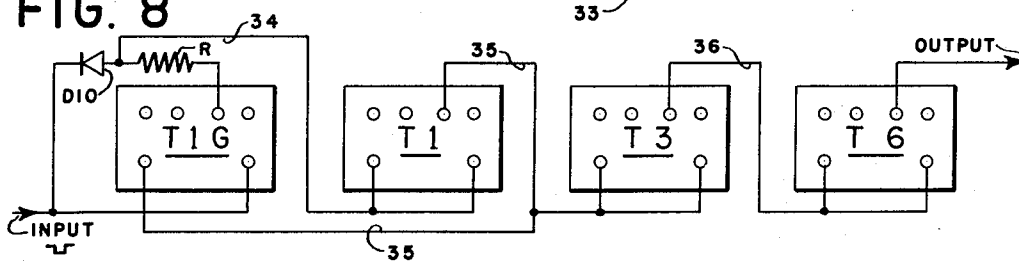


FIG. 8



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2,731,201

ELECTRONIC COUNTER

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Application December 21, 1950, Serial No. 202,120

36 Claims. (Cl. 235—92)

The present invention relates to counters comprising cascade connected electronic triggers and more particularly to means for changing the normal cascade operation of such a series of triggers to operation in the decimal or duo-decimal radix.

In the prior art it is well known to employ a plurality of Eccles-Jordan type triggers connected in cascade as the basis of an electronic counter but these have necessitated means for altering the normal cascade operation in order to produce operation in a chosen radix such as, for example, decade or duo-decimal operation, among others. These altering means have fallen into two chief classes. One class employs feedback means whereby the normal cascade operation of a chosen trigger is blocked and certain counts are eliminated. The feedback permits partial flipping of a trigger but prevents complete flipping of the trigger under operation of counter entry pulses received. This inherently decreases the maximum speed of operation. In another method of the same general class, a blocking tube is utilized in addition to the tubes of the regular triggers which blocking tube is controlled by this feedback and in turn controls a trigger whose flipping in the normal order of cascade operation is thus prevented. In these devices of the prior art, the trigger controlled always entered itself, into the blocking operation.

In a second class of devices of the prior art, certain triggers of the cascade were unnecessarily flipped out of the pure cascade order in order to achieve conversion to a desired radix.

In both these classes, in the prior art, the maximum number of triggers which are flipped to achieve an output pulse at any one time comprised the total number of triggers employed in the cascade. Another disadvantage in the prior art employing feedback correction lay in the fact that this feedback utilized a full plate instead of a plate tap, or direct connections to a grid were employed, both types of these connections being very unstable.

It is, therefore, one of the objects of the present invention to avoid these disadvantages of the prior art by avoiding each of the operations set forth specifically above. These means comprise generally a diode, A. C. coupled on its output to a trigger which is selectively operated or not operated depending upon the relative on and off conditions of two other triggers of the cascade. This is in direct contrast to the utilization of D. C. coupled diodes which are employed in feedback connections of the prior art. Further, such D. C. coupled diodes are employed to flip a trigger one way only, that is, either to an on or to an off condition but are incapable of flipping the trigger to both of these conditions at different times.

Another object of the present invention is to provide simple means for altering the normal cascade operation of a series of triggers, said means comprising a single diode. In order to employ a single diode only and obtain conversion from cascade to operation in another radix, diode coupling cannot be employed since as is obvious from the prior art, a plurality of such diodes are required to achieve the result desired. In order that a single diode

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only will suffice, the novel diode gating means, as disclosed in applicant's copending application Serial No. 197,960 filed November 28, 1950 is employed in the manner as set forth in detail below.

Still another object is to provide novel means for altering the normal cascade operation of a series of triggers said means comprising a diode gate, A. C. coupled to one of the triggers of the cascade and controlled by another of the triggers of the cascade.

Another object is to provide a novel counter comprising four cascade connected triggers and A. C. coupled diode gate means for converting the normal 1-2-4-8 operation of the triggers to 1-2-2-4 operation.

A further object is to provide a novel counter comprising four cascade connected triggers and A. C. coupled diode gating means for converting the normal 1-2-4-8 operation of the triggers to 1-1-2-5 operation.

Another object is to provide a novel counter comprising four cascade connected triggers and A. C. coupled diode gating means for converting the normal binary operation to duo-decade operation.

Still another object is to provide a novel counter comprising four cascade connected electronic triggers and A. C. coupled diode gating means for converting the normal 1-2-4-8 operation to 1-2-4-4 operation.

Another object is to provide a novel counter comprising four cascade connected electronic triggers and A. C. coupled diode gating means for converting the normal 1-2-4-8 operation to 1-2-2-6 operation.

Still another object is to provide a novel electronic counter comprising four cascade connected electronic triggers and A. C. coupled diode gating means for converting the normal 1-2-4-8 operation to 1-1-3-6 operation.

Another object is to provide a novel counter comprising a plurality of electronic triggers connected in cascade and means comprising a single diode only, for converting the normal binary operation to decade operation.

A still further object is to provide a novel counter comprising a plurality of cascade connected electronic triggers and a single diode only, for converting the normal binary operation to duo-decimal operation.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of example, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawings:

Fig. 1 is a wiring diagram of a pair of cross-coupled triodes comprising an electronic trigger employed in the counter.

Fig. 2 is a wiring diagram of one embodiment of a decade counter illustrating the circuit connections among triggers of the type illustrated in Fig. 1.

Fig. 3 is a diagrammatic block diagram illustration of the device of Fig. 2.

Fig. 4 is a diagrammatic block diagram illustration, generally similar to Fig. 3, but illustrating another embodiment of a decade counter.

Fig. 5 is a wiring diagram of an embodiment of a duo-decimal counter illustrating the novel diode gating means and the circuit connections among triggers of the type illustrated in Fig. 1.

Fig. 6 is a diagrammatic block diagram illustration of the device of Fig. 5.

Fig. 7 is a diagrammatic block diagram illustration, generally similar to Fig. 6, but illustrating another embodiment of a duo-decimal counter and;

Fig. 8 is a diagrammatic block diagram illustration, generally similar to Fig. 6, but illustrating still another embodiment of a duo-decimal counter.

Referring to the drawings and more particularly to Fig. 1, there is shown the details of the cross-coupling

circuits for a pair of triodes to form an electronic trigger, the circuit within the rectangular block illustrating the circuits actually included in the blocks of the diagrammatic block diagram figures.

In Fig. 1, the trigger comprises an electronic trigger of the now well-known Eccles-Jordan type comprising a pair of cross-coupled triodes 10 and 11. These are illustrated as being contained within a single envelope and may, for example, comprise a 6J6 type tube but it is to be specifically understood that they may comprise individual tubes if so desired and as is now well known in the art need not necessarily comprise triodes. Further, throughout the specification, certain types of elements and certain values of components are given but it is to be understood that these may be varied within the ambits obvious to those skilled in the art, the values and types specified herein having been found particularly efficacious in the circuits as disclosed.

In Fig. 1, plate P1 of triode 10 is coupled via line 12 and a resistor 13 and condenser 14, in parallel, to the grid G2 of triode 11. The plate P2 is similarly coupled to the grid G1 of triode 10. A value of the resistor 13 which has been found suitable is 200K ohms while the condenser 14 may assume a value of 100 microfarads. The cathodes of the two cross-coupled triodes are joined and connected to ground, as shown. The grid G1 is coupled to the "off" input via a condenser 15 and the grid G2 is coupled to the "on" input via a condenser 16, a suitable value for the condensers 15 and 16 being 40 micromicrofarads each. The grids G1 and G2 are connected via resistors 17 and 18, respectively, to a bias source of minus 100 volts, the values of each of these resistors being 200K ohms. Plate P1 is connected to a source of +150 volts via a pair of resistors 19 and 20, in series, a suitable value for resistor 19 being 12K ohms and of resistor 20 being 7.5K ohms. The plate P2 is similarly connected to the +150 volt source by means of two similar resistors in series, as shown. When a trigger is employed for diode gate control, as described later, more suitable values of each of the resistors 19 and 20 has been found to be 10K ohms each.

As illustrated in Fig. 1, each of the plates P1 and P2 may be provided with a full plate output while each plate is also provided with a tap in the output. As shown, these taps are employed in the interconnections among the triggers, as will be described presently.

As is well known in the art, a trigger of the Eccles-Jordan type has two states of stability. In one state, for example, the triode 11 will be conducting while triode 10 will be cut off. This may be produced by applying a negative pulse to the input labelled "Off" and in the instant application this state of equilibrium in which the triode 10 is non-conducting, as produced by application of such a negative pulse, and with triode 11 conducting, is herein called the "off" state of the trigger. On the other hand, with triode 11 cut off, such as may be produced by a negative pulse applied to the input "On" and with triode 10 conducting, this state of equilibrium is herein called the "on" state. These states of equilibrium are so identified in order to simplify the succeeding description of the operation of the device.

A plurality of triggers, herein shown as four triggers of the type as shown in detail in Fig. 1, are illustrated in Fig. 2, generally connected in cascade. When so connected the operation of the four triggers may be referred to as 1-2-4-8 operation, since one pulse turns "on" the first trigger (assuming that all of the triggers are initially "off") two pulses will turn "off" the first trigger and as it goes "off" it flips "on" the second trigger, etc. Four pulses are required to turn "on" the trigger following the second trigger and eight pulses are required to turn "on" the last trigger. Further, at any one time, it is obvious that the sum of the "labelled" values of each of the triggers which is "on," indicates the total count of the counter.

In order to render such a cascade useful in the normal commercial systems of counting such as, for example, the decimal system in this country or the duo-decimal system in the sterling area, the normal binary operation of four such cascade connected triggers must be altered. Such alteration may change the number of pulses required to initially turn "on" a trigger of the series but does not affect the "weight" of any one trigger in a particular hook-up. Thus, if only the first trigger is "on," the counter count is 1. If the first trigger is "on" and the second trigger is "on," the counter count depends upon the "weight" attached to any trigger above the first, which is "on." That this varies for different counters will be obvious from the following description but, as previously stated, with any one particular counter hookup the "weight" remains fixed for each trigger which is "on," as will be apparent from the following.

Novel means are now provided for producing in an extremely simple manner the alteration, of a generally cascade connected series of triggers which would normally operate in pure binary, to operation in the decimal or duo-decimal system.

Referring to Fig. 2, there is illustrated therein four triggers of the type of Fig. 1 and labelled generally T1, T2G, T2 and T4. These triggers are generally connected in cascade whereby in the normal cascade operation the turning "off" of a preceding trigger will flip the succeeding trigger either "on" or "off" depending upon its status at the time. Assuming that all of the triggers have been reset "off" so that each of the right hand triodes of each of the triggers is conducting, as indicated by the small circles near the right hand side of each envelope. A negative pulse applied to the counter input is also applied to both of the grids of trigger T1 and will flip trigger T1 "on." The plus pulse thus produced on line 21 has no effect, since these triggers will operate only upon the application of negative pulses, with the parameters as indicated.

The second pulse applied to the input of the counter will flip trigger T1 "off." The negative pulse thus produced on line 21 is applied to the grid G2 only of trigger T2G to thus flip this trigger "on." This in turn produces a plus pulse on line 22, which has no effect on trigger T2.

The third pulse applied to the counter input flips trigger T1 "on," with no further effect.

The fourth pulse applied flips trigger T1 "off."

The negative pulse produced on line 21 is no longer effective to flip trigger T2G, since line 21 is connected only to the grid G2 of this trigger and can only flip this trigger "on." When trigger T2G was previously flipped "on" so that its right hand triode became non-conducting, the voltage level at point 23 in the plate circuit was raised which, via the resistor R and line 22 increases the voltage level applied to the plate of the diode Dio. This diode may, for example, comprise a G. E. 1N52 crystal diode, although as pointed out in applicant's copending application Serial No. 197,960, filed November 28, 1950, with certain parameters a tube type diode may be employed.

As stated above, the fourth negative pulse applied to the counter input flips trigger T1 "off" but the negative pulse applied via line 21 is ineffective to flip the trigger T2G since this trigger can only be flipped "on" and it is already "on." However, since the voltage level on the plate side of the diode Dio is now raised, this negative pulse applied via line 21 to the cathode of this diode is effective, via the circuit comprising the resistor R, the diode Dio and its A. C. coupling via condenser K2, for example, in the manner as described in said copending application Serial No. 197,960, to apply via this condenser K2 a negative pulse to the grid G2 of trigger T2 to flip T2 "on." Thus, in effect, as set forth in detail in said copending application, the diode Dio compares the voltages on the two sides of the diode and only when such comparison requires it, the gating action of the diode is employed to apply a negative pulse via the condenser K2,

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for example, to the grid G2 of trigger T2 to flip it "on." The diode Dio always compares the voltages on the two sides thereof and flips its A. C. coupled trigger, when and only when such flipping is required, so that no unnecessary flipping of its controlled trigger is ever produced. Thus, the fourth counter input pulse results in triggers T2G and T2 both being "on." Since the "weight" of each of these triggers is 2, the total count represented at this time for the entire counter is the sum of these two "on" conditions or a total of 4.

The fifth counter input pulse flips trigger T1 "on," with no further effect.

The sixth counter input pulse flips T1 "off" which is effective via line 21 and the A. C. coupled diode network, which this time includes the condenser K1, to apply a negative pulse to the grid G1 of the trigger T2 to flip T2 "off." As T2 flips "off," it produces a negative pulse on line 24, which in turn flips trigger T4 "on." Thus the sixth counter input pulse results in triggers T2G and T4 being "on" an the sum of the "weights" of these two triggers equals 6, which is the correct total count.

The seventh counter input pulse flips T1 "on," with no further effect.

The eighth pulse flips T1 "off" which, in turn, via line 21 and the A. C. coupled diode Dio and condenser K2 flips trigger T2 "on." Thus the eighth counter input pulse results in trigger T2G being "on," T2 being "on" and T4 also being "on," which represents a total count of 8.

The ninth counter input pulse flips T1 "on," with no further effect.

The tenth counter input pulse flips trigger T1 "off." The negative pulse thus produced on line 21 acts via the A. C. coupled diode gate Dio and condenser K1 to flip trigger T2 "off." As T2 goes "off," it produces a negative pulse on line 24 which flips T4 "off." As trigger T4 goes "off," the negative pulse on line 25 is fed back to the grid G1 of the trigger T2G, flipping this trigger "off" so that this tenth counter input pulse returns all triggers to the "off" condition which, as set forth above, is the normal reset condition. The line 25 also serves as an output from the counter so that a negative pulse is available at the "output," on the 10th counter input pulse, as indicated in Fig. 2. This may be applied in the form of a carry to another counter if several of these counters are connected in a chain or as part of an accumulator.

There is illustrated in Fig. 3 the same identical counter as in Fig. 2 the triggers of the counter being shown diagrammatically in block form in order to more concisely highlight the interconnections among the triggers, as illustrated in detail in Fig. 2. The operation of the device as illustrated in Fig. 3 is obviously identical to that described above in connection with Fig. 2.

Referring to Fig. 3 and to the following Table 1, the operation of the counter, shown in detail in Fig. 2, is easily followed. In Table 1, an O indicates that a trigger is "off" while an X indicates that a trigger is "on." Table 1 and Fig. 3 together comprise in effect an extremely brief résumé of the operation in Fig. 2, as set forth in detail above.

Table 1

Counter Input Pulses	Triggers			
	T1	T2G	T2	T4
0.....	O	O	O	O
1.....	X	O	O	O
2.....	O	X	O	O
3.....	X	X	O	O
4.....	O	X	X	O
5.....	X	X	X	O
6.....	O	X	O	X
7.....	X	X	O	X
8.....	O	X	X	X
9.....	X	X	X	X
10.....	O	O	O	O

Referring to Fig. 4, there is illustrated therein a modification of the decade counter of Fig. 2. The scheme of illustration employed in Fig. 3 is also employed in Fig. 4 in order to more sharply accentuate the differences between these respective circuits.

Referring to Fig. 4, there is again illustrated, in block form, four triggers generally connected in cascade. The "weight" to be given to each trigger is indicated by the number following the letter T, the trigger labelled T1G indicating not only that this trigger has a "weight" of 1 but also that this is the trigger which controls the gating operation of the diode. Fig. 4 taken together with the following Table 2 set forth clearly the operation of this embodiment of a decade counter.

Table 2

Counter Input Pulses	Triggers			
	T1G	T1	T2	T5
0.....	O	O	O	O
1.....	X	O	O	O
2.....	X	X	O	O
3.....	X	O	X	O
4.....	O	X	X	O
5.....	X	O	O	X
6.....	O	O	O	X
7.....	X	X	O	X
8.....	X	O	X	X
9.....	X	X	X	X
10.....	O	O	O	O

Referring to Fig. 4 and to the above Table 2, the first counter negative input pulse turns "on" trigger T1G. The second counter input pulse cannot turn "off" T1G since the counter input is connected only to the grid of the right hand triode and not to the grid of the left hand triode. When trigger T1G is flipped "on," the voltage level on the plate of diode Dio is increased since the right hand triode is rendered non-conductive. Therefore, upon application of the second counter input pulse, the voltage on the cathode of diode Dio is sharply reduced and by the now well understood gating action of diode Dio, flips "on" trigger T1, as indicated in Table 2. The third counter input pulse also has no effect on trigger T1G but produces flipping "off" of trigger T1, as indicated in Table 2, which in turn flips "on" trigger T2. The fourth counter input pulse operation will be clear from Table 2.

The fifth counter input pulse does not directly affect trigger T1G but does flip trigger T1 "off" by means of the gating action of diode Dio. This, in turn, flips "off" trigger T2, which does two things. It flips "on" trigger T5 and also, via line 26, applies a negative pulse to the grid of the left hand triode of trigger T1G to flip it "off," all as indicated in Table 2. The sixth counter input pulse flips trigger T1G "on" but since trigger T1G was previously "off" thus lowering the voltage level on the plate of diode Dio, no gating action ensues and trigger T1 remains "off," as indicated in Table 2. The seventh counter input pulse is ineffective to flip trigger T1G but since the sixth pulse left this trigger "on," the voltage level was raised on the plate of diode Dio, so that this seventh negative input pulse is effective, by means of the diode gating action, to flip trigger T1 "on." The eighth pulse is effective to flip T1 "off," as indicated in Table 2, which in turn flips T2 "on." The ninth counter input pulse flips T1 "on" by means of the gating action of diode Dio.

The tenth counter input pulse flips T1 "off" which, in turn, flips T2 "off." When T2 is thusly flipped "off," it performs two operations. It flips "off" T5 and also, via line 26, applies a negative pulse to the grid of the left hand triode of trigger T1G, to flip this trigger "off," all as indicated in Table 2. Thus the device of Fig. 4 is returned to normal reset condition and an output pulse is produced at the "output" of trigger T5, as indicated in Fig. 4, upon application of the tenth counter input pulse to the input of the counter.

Referring to Fig. 5, illustrated therein is a counter generally similar to that of Fig. 2 but one in which the normal binary cascade operation of four triggers is converted to operation in the duo-decimal system. The operation is generally similar to that of Fig. 2 and will be discussed briefly by means of the following Table 3 which illustrates in tabular form the operation thereof:

Table 3

Counter Input Pulse	Triggers			
	T1	T2	T4G	T4
0.....	0	0	0	0
1.....	X	0	0	0
2.....	0	X	0	0
3.....	X	X	0	0
4.....	0	0	X	0
5.....	X	0	X	0
6.....	0	X	X	0
7.....	X	X	X	0
8.....	0	0	X	X
9.....	X	0	X	X
10.....	0	X	X	X
11.....	X	X	0	X
12.....	0	0	0	0

Referring to Fig. 5 and Table 3, the first negative counter input pulse flips T1 "on." The second counter input pulse flips T1 "off" which in turn applies a negative pulse via line 27 to the grids of T2, to flip T2 "on." The operation on the third, fourth, fifth, sixth and seventh pulses is as clearly shown in Table 3.

The eighth counter input pulse flips T1 "off" which applies a negative pulse to line 27 to flip T2 "off" and T2 in going "off" applies a negative pulse via line 28 to the grid of the right-hand triode only, of trigger T4G but since this trigger is already "on," it merely remains "on." When T4G was turned "on," it applied an increased voltage level to the plate of diode D10 so that this negative pulse now applied via line 28 to the cathode of D10 is effective by the gating action of D10, line 29 and condenser K2 to apply a negative pulse to the grid of the right-hand triode of T4, to flip it "on," as indicated in Table 3.

The ninth counter input pulse turns "on" T1, as shown in Table 3. The tenth pulse flips T1 "off" which in turn flips T2 "on." The eleventh pulse turns T1 "on."

Upon application of the twelfth counter input pulse, T1 is turned "off." This applies a negative pulse via line 27 to flip T2 "off." T2 in going "off" applies a negative pulse via line 28 to the grid of the right-hand triode of T4G but since T4G is already "on," this pulse has no effect. With T4G "on," the voltage level on the plate of D10 is relatively high so that the negative pulse on line 28 applied to the cathode of D10 is effective by means of the diode gating action of D10, line 29 and condenser K1, to apply a negative pulse to the grid of the left-hand triode of T4, turning T4 "off." As T4 goes "off," it applies a negative pulse via line 30 which serves as an "output" to the next duo-decimal counter. By means of line 30, a negative pulse is also fed back to the grid of the left-hand triode of T4G turning this trigger "off." Thus, on the twelfth counter input pulse, all of the triggers are restored to the normal reset condition and an output pulse indicative of a count of 12 is available at the "output," as indicated in Fig. 5.

Fig. 6 is a diagrammatic block diagram illustration of the circuit of Fig. 5 high-lighting the interconnections among the respective triggers.

Fig. 7 is a diagrammatic block diagram illustration of another embodiment of the duo-decimal counter, generally of the type of Fig. 5, but illustrated diagrammatically along the lines of Fig. 6 in order to succinctly set forth the

distinctions. Referring to Fig. 7 and to the following Table 4, the operation will now be described:

Table 4

Counter Input Pulse	Triggers			
	T1	T2G	T2	T6
0.....	0	0	0	0
1.....	X	0	0	0
2.....	0	X	0	0
3.....	X	X	0	0
4.....	0	X	X	0
5.....	X	X	X	0
6.....	0	0	0	X
7.....	X	0	0	X
8.....	0	X	0	X
9.....	X	X	0	X
10.....	0	X	X	X
11.....	X	X	X	X
12.....	0	0	0	0

The first counter negative input pulse flips T1 "on." The second pulse flips T1 "off" which applies a negative pulse via line 31 to the grid of the right-hand triode of T2G to flip it "on." With T2G "on," the voltage level on the plate side of the diode D10 is raised. The third pulse turns T1 "on," with no further effect, as is obvious from Table 4.

The fourth pulse flips T1 "off." The negative pulse thereby produced on line 31 is ineffective to flip trigger T2G, since this trigger is already "on." However, this negative pulse on line 31 is applied to the cathode of diode D10 whose plate voltage level is now relatively high since T2G is "on." Thus by the diode gating action of D10, a negative pulse is applied via line 32 to the grids of T2, to flip it "on."

The fifth pulse flips T1 "on," with no further effect.

The sixth input pulse flips T1 "off." The negative pulse thereby produced on line 31 has no effect on T2G since it is already "on" but the diode gating action of D10 flips T2 "off." As T2 flips "off," it applies a negative pulse via line 33 to flip T6 "on" in normal fashion. Also, via line 33, a negative pulse is applied to the grid of the left-hand triode of T2G, to flip it "off."

The seventh pulse flips T1 "on," with no further effect. The eighth pulse flips T1 "on" which in turn via line 31 flips T2G "on" so that the voltage level on the plate of D10 is raised preparing it for gating action. The ninth pulse turns T1 "on," with no further effect. The tenth pulse turns T1 "off." The negative pulse thereby produced on line 31 has no effect on T2G since it is already "on." By the diode gating action of D10, a negative pulse is applied via line 32 to flip T2 "on." The eleventh pulse flips T1 "on" with no further effect.

The twelfth counter input pulse flips T1 "off." The negative pulse on line 31 has no effect on T2G since it is already "on." This negative pulse on line 31, however via the gating action of diode D10 and line 32 flips T2 "off." T2 in going "off" applies a negative pulse via line 33 to the grid of T6 to flip it "off" thus producing a negative pulse on the "output." The negative pulse on line 33 is also applied to the grid of the left-hand triode of trigger T2G, flipping it "off," so that the counter is returned to the normal reset condition upon application of this twelfth counter input pulse.

Referring to Fig. 8, diagrammatically disclosed therein is another embodiment of a duo-decimal counter, generally of the type of Fig. 5 but again illustrated diagrammatically in block diagram form along the lines of Figs. 6 and 7. By reference to Fig. 8 and the following Table 5, the operation of the device will be clear:

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Table 5

Counter Input Pulse	Triggers			
	T1G	T1	T3	T6
0.....	O	O	O	O
1.....	X	O	O	O
2.....	X	X	O	O
3.....	O	O	X	O
4.....	X	O	X	O
5.....	X	X	O	O
6.....	O	O	O	X
7.....	X	O	O	X
8.....	X	O	O	X
9.....	O	O	X	X
10.....	X	O	X	X
11.....	X	X	X	X
12.....	O	O	O	O

The first counter negative input pulse flips T1G "on." With T1G "on," the voltage level at the plate of diode D10 is relatively increased so that when the second counter input pulse is applied, it is effective, by means of the diode gating action of diode D10, to apply a negative pulse, via line 34, to flip T1 "on." This second counter input pulse is ineffective to flip T1G since it is applied only to the grid of the right-hand triode thereof and T1G is already "on," by means of the first counter input pulse. The third input pulse by means of the diode gating action of diode D10 applies a negative pulse via line 34 to flip T1 "off." This applies a negative pulse via line 35 to flip T3 "on" and also via line 35 to flip T1G "off." The fourth input pulse flips T1G back "on," so that again the relative voltage level at the plate side of D10 is raised so that upon application of the fifth counter input pulse, T1 is flipped "on" by the gating action of diode D10. The sixth pulse has no direct effect on T1G but by means of the gating action of diode D10 flips T1 "off" which in turn via line 35 flips T3 "off" which in turn via line 36 flips T6 "on." The negative pulse on line 35 is also fed back to the grid of the left-hand triode of T1G to flip it "off." The seventh pulse flips T1G "on," so that diode D10, on the eighth pulse flips T1 "on." The ninth pulse has no direct effect on T1G but by means of the gating action of diode D10 flips T1 "off" which via line 35 flips T3 "on" and T1G "off." The tenth pulse flips T1G "on" so that the D10 is effective on the eleventh pulse to flip T1 "on."

The twelfth counter input pulse has no direct effect on T1G but by means of the diode gating of diode D10 flips T1 "off." This in turn via line 35 flips T3 "off" which via line 36 flips T6 "off" to produce a pulse on the line marked "Output" on the twelfth input pulse to the counter. The negative pulse on line 35 also flips T1G "off" so that the counter has been reset to the original reset condition.

It is thus seen that there are disclosed two general types of counters. One comprises a plurality of four cascade-connected electronic triggers whose normal binary operation is changed to decade operation by means of diode gating means which compare the voltages on two sides of the diode and flip a trigger when and only when the comparative voltages require such flipping. Thus unnecessary operation of any triggers is avoided. Similarly by employing the novel diode gating means, there is no blocking and no partial flipping of triggers and the number of triggers flipped in any decade run is maintained at a minimum. Various patterns of decade operation are disclosed.

Similarly, a plurality of patterns of duo-decimal operation of a similar group of four cascade-connected electronic triggers are disclosed, utilizing the high efficiency, speed of operation and selective trigger operation produced by diode gating.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a plurality of embodiments, it will be understood that various omissions and substitutions and

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changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. An electronic counter comprising at least four bi-stable devices connected in cascade, an input and an output for said cascade and means for altering the number of pulses required to be applied to said input to produce an output, said alteration being from the number that would be required during unaltered straight cascade operation to a lesser number, said means for altering comprising one single diode only controlled by a single one only of said devices for operation by a pulse to selectively flip or not to flip one other device only in accordance with the on or off status of said controlling device.

2. An electronic counter comprising at least four cascade-connected bi-stable devices, an input and an output for said cascade, said output being effective under control of a selected number of pulses applied to said input, and means for altering the number of pulses required to produce such an output said alteration being from the number that would be required during unaltered straight cascade operation to a lesser number, said means for altering comprising one single diode only controlled by a single one only of said bi-stable devices to selectively produce or not to produce operation of another bi-stable device under control of an operating pulse in dependence upon the on or off condition of said controlling bi-stable device, said diode means being A. C. coupled to the controlled bi-stable device.

3. A counter comprising at least four cascade-connected bi-stable devices, a source of pulses for operating said bi-stable devices, an input to said counter to which said pulses are applied, an output for said counter effective upon application of a predetermined number of pulses to said input which number is less than the number which would be required to produce an output upon straight cascade operation of said bi-stable devices, and means for fixing said predetermined number of pulses required to produce an output comprising voltage comparing means, said means comprising one single diode only operable only with a predetermined difference of potential level on the two sides of said diode produced by the operation of two bi-stable devices only of said bi-stable devices for operating one of the other bi-stable devices of the cascade out of its normal cascade operation.

4. A counter comprising at least four cascade-connected bi-stable devices, and means for altering the number of pulses required to be applied to the input of said counter to produce an output, said alteration being from the number required for unaltered straight cascade operation to a lesser number, and including, one single diode only controlled by two bi-stable devices only of said cascade comparing the electrical status of one of said two bi-stable devices and that of the other of said two bi-stable devices, said single diode being effective to flip a succeeding bi-stable stable device only when the status of said two bi-stable devices is different.

5. A counter comprising a plurality of cascade-connected electronic triggers and a coupling device between two of said triggers comprising a diode, a resistor connected to one side of said diode, one of said triggers while being flipped comprising a source of rapidly varying potential to be applied to the other side of said diode and the other one of said two triggers comprising means for altering the level of potential applied through said resistor to said one side of said diode upon alteration of the on and off status of said one trigger and means including a capacitor connected between said diode and resistor and connected to still another trigger for delivering an operating voltage upon assumption of one status by said other trigger and production of said rapidly varying potential by said one trigger.

6. A counter comprising a plurality of cascade-connected electronic triggers and a coupling device between two of said triggers comprising a diode, a resistor connected to one side of said diode, one of said triggers being connected to the other side of said diode whereby upon operation of said one trigger a rapidly varying potential is applied to said diode, the other one of said two triggers being connected to the other end of said resistor and operable to produce a change in the level of potential upon said one side of said diode upon alteration of the on and off conditions of said one trigger and means including a capacitor for connecting the point between said one side of said diode and said resistor to a third one of said triggers whereby said third trigger is flipped when the level of potential on one side of said diode is increased and said rapidly varying potential is applied to the other side thereof while said third trigger remains in its then status when the level of potential on said one side of said diode is relatively low.

7. A counter comprising a plurality of cascade-connected electronic triggers each operable to two conditions of stability and a coupling device for certain of said triggers comprising a diode connected at one side to one of said triggers whereby upon operation of said trigger to one condition of stability a rapidly varying potential varying in one direction is applied to said side of said diode, a network comprising a resistor connected to a condenser, means connecting one end of said network to another of said triggers and the other end of said network to a third one of said triggers and the other side of said diode to the connection between said resistor and condenser, said other end of said network being operable to deliver a flipping pulse to said third trigger only upon assumption of a chosen status of said second trigger and production of said varying potential by the operation of the first of said triggers.

8. A counter comprising at least four cascade-connected bi-stable devices, and means for coupling certain ones only of said bi-stable devices to produce by the action of said means, an output from said counter and comprising one single A. C. coupled diode only connected at one side to one of said bi-stable devices, at the other side to a second of said bi-stable devices and operable to produce a flipping pulse to a third one of said devices via said A. C. coupling, only upon assumption of one condition of stability by the second of said devices but not the other condition of stability and upon operation of the first of said devices to produce a varying potential rapidly varying in one chosen direction but not when varying in the other direction.

9. A counter comprising a plurality of four cascade-connected bi-stable devices and means to produce by the action of said devices an output from said counter and comprising a circuit coupling the first, second and third of said devices including one single diode only, means connecting one side of said diode to a plate output of one device, means connecting the same side of said diode to a control element of a second of said devices, means, including a resistor, connecting the other side of said diode to a plate output of said second device and means coupling said other side of said diode to a control element of the third of said devices.

10. An electronic counter comprising a plurality of four cascade-connected bi-stable devices and means for altering the normal cascade operation of said bi-stable devices to produce by the action of said devices an output from said counter and comprising a circuit whereby operation of the first of said devices alone to on condition represents a count of one, operation of the second of said devices alone, to on condition, a count of two, operation of the third of said devices alone, to on condition, a count of two, and operation of the fourth of said devices to on condition, a count of four, the combined on conditions of any of the four representing the sum of the sole counts, said means comprising a single A. C.-coupled diode only,

D. C. connected to two of said devices and A. C.-coupled to another one of said devices.

11. A counter comprising a plurality of four cascade-connected triggers, means including a single diode and resistor in series connected between the plates of two successive triggers and A. C.-coupling means connected at one end between one side of said diode and its series resistor and at its other end to a control element of a third of said triggers and including means connecting the output of said counter and a control element of the second trigger of said series.

12. A counter comprising a plurality of four cascade-connected electronic triggers and means for coupling two of said triggers comprising a single diode, a resistor in series with said diode, the free end of said resistor being coupled to a plate output of the first one of said triggers, a source of pulses for said counter, means applying said pulses to one of said triggers and to one side of said diode, a tap between the other side of said diode and its series resistor and means A. C. coupling said tap with a control element of another of said triggers.

13. A device as in claim 12, said A. C. coupling means interconnecting said tap and both control elements of said other trigger.

14. A counter comprising a plurality of four cascade-connected triggers and means for coupling the first and second of said triggers comprising a single diode, resistance means connecting one side of said diode to a plate output of the first of said triggers and a condenser coupling said same side of said diode to the control elements of the second of said triggers, a source of pulses to be counted and means connecting said source to one control element only of said first trigger and to the other side of said diode.

15. A counter comprising four electronic triggers connected in cascade, a source of input pulses, means interconnecting an output of the third of said triggers and an input of the first of said triggers, means applying said input pulses to another input of said first trigger, a single diode, means applying said pulses to one side of said diode, a resistor connected at one end to one side of said diode and at the other end to an output of said first trigger and means A. C. coupling said same side of said diode and the inputs of the second of said triggers.

16. A counter comprising four cascade-connected electronic triggers and means for altering the normal cascade operation of said triggers to produce by the action of said means an output from said counter upon the application of a number of input pulses less than the number required to produce an output with normal cascade operation, whereby the on condition of the first trigger alone, represents one, the on condition of the second trigger alone, represents one, the on condition of the third trigger alone, represents two and the on condition of the fourth trigger alone, represents five, said means comprising one single A. C.-coupled diode only coupling two only of said triggers.

17. A counter comprising four cascade-connected electronic triggers and means for altering the normal cascade operation comprising a single diode, means connecting one side of said diode to an output of the second trigger, means including a resistor connecting the other side of said diode and the output of the third of said triggers and A. C. coupling means connected between said resistor and said other side of said diode and to an input of the fourth of said triggers.

18. A device as in claim 17 and including means connecting the output of said counter and an input of the third of said triggers.

19. A counter comprising four cascade-connected electronic triggers and means for altering the normal cascade operation of said triggers to produce by the action of said means an output from said counter upon the application of a number of input pulses, less than the number required to produce an output with normal cascade operation so that the on condition of the first of said triggers

alone, represents one, the on condition of the second of said triggers alone, represents two, the on condition of the third of said triggers alone, represents four and the on condition of the fourth of said triggers alone, represents four, said means comprising one single A. C. coupled diode only coupling two only of said triggers and operable to operate another of said triggers out of its normal cascade operation.

20. A device as in claim 19 and including a connection between an output of the fourth of said triggers and a single input only of the third of said triggers.

21. A device as in claim 19, said diode being connected at its cathode side to an output of said second trigger and at its plate side to an output of a third of said triggers and to both inputs of said fourth trigger.

22. A counter comprising four cascade-connected electronic triggers and means for altering the normal cascade operation of said triggers so that the on condition of the first of said triggers alone represents one, the on condition of the second of said triggers alone, represents two, the on condition of the third of said triggers alone, represents four and the on condition of the fourth of said triggers alone, represents four, said means comprising a single A. C.-coupled diode coupling two of said triggers and operable to operate another of said triggers out of its normal cascade operation, said diode being connected at its cathode side to an output of said second trigger and at its plate side to an output of a third of said triggers and to both inputs of said fourth trigger, said connection between the plate side of said diode and said output of said third trigger being resistive and said connection between said plate side of said diode and said fourth trigger being capacitive.

23. A counter comprising four cascade-connected bi-stable devices and means for altering the normal cascade operation to produce by the action of said device an output from said counter upon the application of a number of input pulses less than the number required to produce an output with normal cascade operation, said means comprising one single diode only, means connecting one side of said diode to an input of the first bi-stable device and to an input of the second bi-stable device and means connecting the other side of said diode to an output of said second bi-stable device and to an input of the third bi-stable device.

24. A counter comprising four cascade-connected bi-stable devices and means for altering the normal cascade operation comprising a single diode, means connecting one side of said diode to an output of the first bi-stable device and to an input of the second bi-stable device, means connecting the other side of said diode to an output of said second bi-stable device and to an input of the third bi-stable device, one of said last two connections being resistive and the other capacitive.

25. A device as in claim 24, and means connecting an output of said third bi-stable device and an input of said second bi-stable device.

26. A counter comprising a plurality of four cascade-connected triggers and means for altering the normal cascade operation to produce by the action of said means an output from said counter upon the application of a number of input pulses, less than the number required to produce an output with normal cascade operation whereby the on condition of the first trigger alone, represents one, the on condition of the second trigger alone, represents two, the on condition of the third trigger alone, represents two and the on condition of the fourth trigger alone represents six, said means comprising one single diode only D. C. coupling two of said triggers and A. C. coupling a different two of said triggers.

27. A counter comprising a plurality of four cascade-connected triggers and means for altering the normal cascade operation whereby the on condition of the first trigger alone represents one, the on condition of the second trigger alone represents two, the on condition

of the third trigger alone represents two, and the on condition of the fourth trigger alone represents six, said means comprising a single diode, D. C. coupling two of said triggers and A. C. coupling a different two of said triggers, said D. C. coupling means comprising a direct connection between one side of said diode and an input of one trigger and the output of another, and a resistor, connected between the other side of said diode and an output of one of said two triggers, and said A. C. coupling comprising a condenser coupling the tap between said resistor and diode and an input of another of said triggers.

28. A device as in claim 27, and including a connection between an output of the third trigger and an input of the second.

29. A counter comprising four cascade-connected bi-stable devices and means for altering the normal cascade operation comprising a single diode, a source of pulses to be counted, means connecting said source to one side of said diode and to one input of the first of said bi-stable devices, and a resistive connection between the other side of said diode and one of said bi-stable devices and a capacitive connection between said other side and another of said bi-stable devices.

30. A device as in claim 29, said resistive connection being between an output of the first of said triggers and said other side of said diode and said capacitive connection being to an input of the second of said triggers.

31. A device as in claim 30, and a connection between an output of said second trigger and an input of said first trigger.

32. A counter comprising four cascade-connected triggers and means for altering the normal cascade operation whereby the on condition of said first trigger alone, represents one, the on condition of the second trigger alone, represents one, the on condition of the third trigger alone, represents three and the on condition of the fourth trigger alone, represents six, said means comprising a single diode, a source of pulses to be counted, means connecting said source to one side of said diode and to an input of the first of said triggers, and means resistively and capacitively connecting the other side of said diode to two others only of said four triggers respectively.

33. A device as in claim 32, said resistive connection being to an output of the first trigger and said capacitive connection to an input of the second of said triggers.

34. A device as in claim 33, said capacitive connection being to both inputs of said second trigger.

35. A device as in claim 33 and including a connection from an output of said second trigger to an input of said first trigger.

36. A selective transfer unit for use in binary computing and counting devices having a plurality of multi-vibrator storage units, each of said storage units having two oppositely designated anodes and a triggering input terminal; said transfer unit comprising impedance elements, including two resistors, a rectifier, and a capacitor connected to a common junction point in star relationship and providing at the respective ends of said impedance elements opposite said junction a first resistor terminal for connection to an anode of one of said storage units, a second resistor terminal for connection to a source of direct potential, a rectifier terminal for connection to the triggering input terminal of another of said storage units, and a capacitor terminal for transmitting triggering pulses.

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