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J. A. IRVINE ET AL

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ELECTRONIC COUNTERS

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FIG. 1.

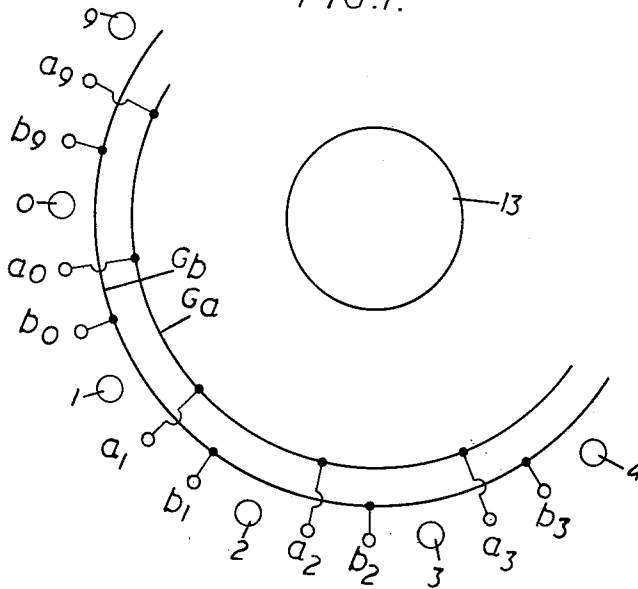
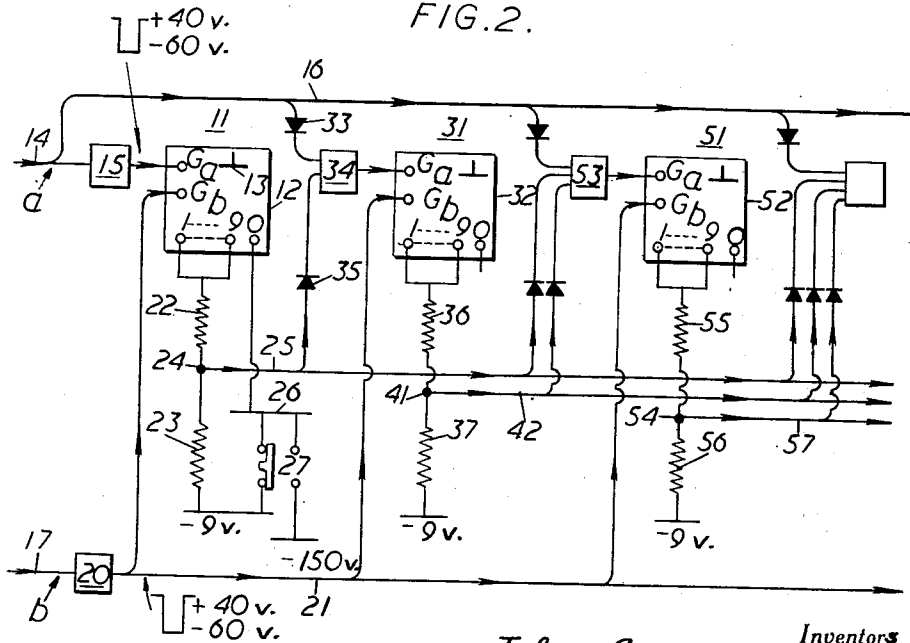


FIG. 2.



John Anderson Irvine
Garin Mowat Rendall
By
Cameron, Kerkam & Sutton
Attorneys

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ELECTRONIC COUNTERS

John Anderson Irvine, Dunfermline, Fife, and Gavin Mowat Rendall, Edinburgh, Scotland, assignors to Ferranti, Limited, Hollinwood, England, a company of Great Britain and Northern Ireland

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4 Claims. (Cl. 315—84.6)

This invention relates to electronic counters and specifically to reversible multistage counters of the kind employing at each power stage a glow-discharge counter tube having a circular array of cathodes, one for each digit, and having two guide-rails with electrodes in close association with the cathodes so that the successive application of pulses to the guide-rails causes the glow-discharge to be transferred from cathode to cathode as the count proceeds.

The invention has particular application where the numerical system is the decimal system, each discharge tube having ten cathodes and being usually known as a dekatron; the invention will accordingly be described in that connection but it should be understood that its application is not limited to the decimal system but has application to numerical systems where the radix is other than ten.

It is usual to operate a dekatron by pairs of overlapping pulses, one pair for each unit, applied to the respective guide-rails of the tube over independent channels. For ease of reference these pulses will hereinafter be designated *a* and *b* respectively. By applying the pulses on the order *ab* a unit is added to the count, whereas by applying them in the order *ba* a unit is subtracted. Such a counter is known as a reversible counter and has wide applications.

In addition to the ten cathodes 0 to 9 (see Fig. 1 of the accompanying drawings) and the common anode 13, each tube contains first and second circular guide-rails G_a and G_b concentric with the ring of the cathodes. One rail receives all the *a* pulses and the other all the *b* pulses. Each rail has ten electrodes a_0 to a_9 and b_0 to b_9 respectively, extending radially from the rail into the respective spaces between the cathodes. Between each pair of adjacent cathodes, therefore, are an *a* and a *b* electrode spaced in that order in the direction for increasing the count. Hence the *a* electrode is nearer the "lower" of the two cathodes and "above" it, whilst the *b* electrode is nearer the "higher" cathode but below it, the terms "lower," "higher," "above" and "below" referring to the integers represented by the cathodes.

In known counters such a tube is so arranged that in the absence of the pulses the glow remains directed to whichever of the cathodes it was transferred on the application of the previous pulse pair. Each cathode is marked to indicate the integer it represents and the visible display resulting from the direction of the glow to this cathode affords a clear indication of the total counted.

The known action of the tube in counting from a given number—2, say—will now be briefly described. On the application of a pulse pair *ab* representing a unit to be added, the *a* pulse energises negatively the G_a rail and hence all ten *a* electrodes in advance of the arrival of the *b* pulse. As a consequence the glow is attracted from cathode 2 to the electrode a_2 above it, since this is now at a lower potential than the cathode. The electrode a_1 below cathode 2 will of course be energised too, but the glow is not attracted to this electrode since it is further

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away, being in fact separated from cathode 2 by electrode b_1 . Similarly the glow will not be attracted to the other *a* electrodes, since these are still further away. Similarly on the arrival of the *b* pulse; though all the *b* electrodes are energised the only one that influences the glow is the nearest one; electrode b_2 , below the next higher cathode, cathode 3; accordingly the glow is transferred to electrode b_2 . Consequently on the cessation of the *b* pulse the glow passes to cathode 3, the count of one being thereby effected.

Similarly when the unit is to be subtracted from the count. The *b* pulse this time arrives first and transfers the glow from cathode 2 to the nearest *b* electrode—the one just below it, b_1 . The *a* pulse transfers the glow to the nearest *a* electrode—the one just above cathode 1, a_1 . On the cessation of the *a* pulse the glow passes to the nearest cathode—cathode 1.

A single tube, of course, only counts over the range 0 to 9. Where a higher count is required, therefore, a multistage assembly of tubes in cascade is usually employed, the first tube counting and indicating the units, the next the tens, the next the hundreds, and so on, to the limit required, each tube other than the units tube being driven from the zero cathode of the preceding tube. More broadly, a tube is required for each power of the radix concerned, up to the limit desired.

Such a known form of multistage counter has several disadvantages. In the first place it is not easy to design the counter so as to ensure the preservation of the reversible action in the higher stages, since after the first stage the pulse pairs for the operation of each higher stage are normally derived from the single pulse or step waveform appearing at the zero cathode of a preceding stage, and the sequence of the original pulse pairs applied to the first stage is lost. To overcome this difficulty it is generally necessary to provide some sort of discriminator to determine which of the original pulse pairs denote addition and which subtraction and to pass the output from the discriminator through somewhat elaborate gating stages to determine the correct direction of count in each counter stage.

Another disadvantage is that the delays in the transfer of pulses from one stage to the next are cumulative and this imposes an overall delay on the rate of counting in order to avoid errors.

A further disadvantage arises where a valve amplifier is inserted between counter tubes of successive stages. It is usually desirable for the guide-rails in their normal condition—that is, when not energised by a pulse—to be at a standing D.C. potential of about 80 to 100 volts lower than the mean potential of the anode. A potentiometer coupling may be used to provide this drop between the amplifier output and the counter tube input but this arrangement results in much loss by attenuation and requires a high tension supply of undesirably high level.

An object of the present invention is to provide a reversible multistage electronic counter in which these disadvantages of known counters are to a substantial extent eliminated.

A particular object is to produce such a counter which is capable of operating at a higher speed and with greater accuracy than counters as hitherto disclosed.

A further object is to provide such a counter having fewer components than known counters.

In accordance with the present invention, a reversible multistage electronic counter for operation by pairs of sequential overlapping voltage pulses *a* and *b* in either order, each pair in the order *ab* represents a unit to be added to the count and in the order *ba* representing a unit to be subtracted from the count, includes for each numerical power required a glow-discharge counter tube

of the kind having a circular array of digit-representing cathodes surrounding a common anode, each pair of adjacent cathodes having between them and individual to them first and second electrodes spaced in that order in the direction of increasing the count, each tube having first and second guide-rails common to all the cathodes of the tube and connected to all the first electrodes and to all the second electrodes of the tube respectively, means for applying in a negative-going sense each *a* pulse to the first rails of all the tubes simultaneously, and each *b* pulse to the second rails of all the tubes simultaneously, and for each tube, except that for the highest power, inhibiting means, operative when the discharge of the tube is directed to any of the digit cathodes of the tube which represent digits other than zero, to inhibit the counting action of the tube of each higher power whilst the glow remains directed to that cathode.

Each inhibiting means may include a common load for the said digit cathodes of the tube which represent digits other than zero and connections for applying the voltage developed across said load in a negative-going sense to the first guide-rail of each of the tubes of the higher powers.

In the accompanying drawings,

Figure 1 is a sectional view of a part of a known kind of dekatron counter tube, and Figure 2 is a schematic diagram of a multistage counter in accordance with one embodiment of the invention.

In carrying out the invention in accordance with one form by way of example, a reversible multistage counter includes a unit stage 11—see Fig. 2—having a dekatron tube 12, which is assumed to be of the known kind described above with reference to Fig. 1. The guide-rails are shown at G_a and G_b and the anode at 13. Only the cathodes representing the digits 1, 9, and 0 are shown in Fig. 2. The *a* pulses are applied in a positive-going sense over a channel 14 to a single-stage amplifier 15 and thence in a negative-going sense to rail G_a of the tube. These pulses are also applied in a positive-going sense to a channel 16 common to all the higher stages. The *b* pulses are applied in a positive-going sense over a channel 17 to a single-stage amplifier 20 and thence in a negative-going sense to a channel 21 common to all stages. The rail G_b of tube 12 is connected to this channel. Cathodes 1 to 9 are commoned and connected to a source of -9 volts by way of resistors 22 and 23 (forming part of the inhibiting means) in series. The common point 24 of these resistors is connected to an inhibiting channel 25 common to all the higher power stages. The zero cathode is connected to a lead 26 common to all stages. A switch of conveniently the push-button type connects this lead selectively to sources of -9 and -150 volts, the -9 volt source being connected to the lead when the switch is in its normal position. Anode 13 is connected by way of a load resistor to a source of about +400 volts; these connections are omitted for clarity.

The tens power stage 31 includes a dekatron tube 32 similar to tube 12. The *a* pulses, derived from channel 16, are applied to rail G_a of this tube by way of a diode 33 and a single-stage amplifier 34. A connection to the input of this amplifier is also made from channel 25 by way of a diode 35. Rail G_b is connected to channel 21. Cathodes 1 to 9 are connected to the -9 volt source by way of resistors 36 and 37 in series the common point 41 of which is connected to an inhibiting channel 42 common to all higher power stages. The zero cathode is connected to lead 26; this connection is omitted for clarity.

The hundreds stage 51, with dekatron tube 52 and amplifier 53, is similar to stage 31 except that the input to amplifier 53 includes in addition to the connection from channels 16 and 25 a connection from inhibiting channel 42. The common point 54 of the two resistors 55 and 56 in the common lead from cathodes 1 to 9 of the tube is

applied by way of an inhibiting channel 57 to all the higher power stages.

The diodes in the respective input leads to amplifiers 34 and 53 and to the corresponding amplifiers of the higher power stages (not shown) are connected in the sense for passing positive-going pulses. These diodes are inserted to prevent a permanent coupling between channels 16 and 25.

The remaining stages are arranged on the same principle as stage 51; each receives as input to its amplifier a connection from each inhibiting channel from a lower-power stage and itself supplies an inhibiting channel to each of the higher-power stages.

The operation of the counter in counting upwards from zero will now be described.

In the quiescent condition of the counter, that is, as at first switched on, the potential of each guide-rail is +40 volts and each cathode -9 volts. The glows in the respective tubes are therefore directed to the respective cathodes at random. To prepare the apparatus for a count, therefore, switch 27 is depressed momentarily, thereby lowering the potential of each zero cathode to -150 volts to attract the glow to it. The counter now indicates a "0" in each tube.

Suppose now a signal representing a unit to be counted is applied to the counter. As already explained, the signal is in the form of an *a* pulse followed and overlapped in time by a *b* pulse, i.e. the sequence *ab*, the pulses being applied in a positive-going sense over channels 14 and 17 respectively. Hence each *a* pulse, on its arrival, is applied by way of channel 14 to all the counter tubes simultaneously, reaching the respective G_a rails in a negative-going sense. Similarly each *b* pulse, on its arrival, is applied by way of channel 21 in a negative-going sense to all the G_b rails simultaneously.

Pulse *a*, arriving first, causes amplifiers 15, 34, 53 etc. to become conductive, thereby carrying all the rails G_a and their electrodes simultaneously down to -60 volts and attracting each glow to the electrode a_0 (see Fig. 1) just above the zero cathode. Before this pulse has ended, and accordingly whilst the glows are still directed to the respective a_0 electrodes, the *b* pulse arrives in a negative-going sense in channel 21, carrying each rail G_b down to -60 volts. Consequently when the *a* pulse ceases all the amplifiers 15, 34, 53 etc. are cut off and the positive bias potential of the *a* rails is restored. The glow in each tube has therefore now been transferred from electrode a_0 to the nearest *b* electrode, electrode b_0 , which is just below cathode 1.

When the *b* pulse ceases, the glow in each tube begins to transfer to cathode 1 and in each stage current begins to flow in the load common to cathodes 1 to 9. The effect of this in stage 11 is to raise the potential of point 24 sufficiently to render the amplifier 34, 53, etc. of each higher power stage again conductive and so restore the negative potential to the rail G_a . Hence whereas in stage 11 the glow passes to cathode 1, the glow in each higher stage returns to electrode a_0 before it has had time to establish itself fully on cathode 1. In this manner the first stage of the counter derives and applies to each of the higher stages over channel 25 a voltage to inhibit the counting action of each higher tube.

The above conditions obtain so long as the glow in tube 12 is directed to cathode 1—that is to say, the glow in each of the higher tubes remains directed to electrode a_0 . The closeness of this electrode to the zero cathode causes each of these tubes to indicate substantially the integer "0," the overall display being "... 0001."

The arrival of another pulse pair *ab* representing a unit to be added to the count causes the glow in tube 12 to be stepped by way of electrodes a_1 and b_1 to cathode 2. In each higher tube, on the other hand, owing to the inhibiting action exercised by the first stage 11 of the counter, the *a* pulse has no effect, since the glow is

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already directed to an *a* electrode. The *b* pulse causes the glow to be transferred to electrode b_0 and on the cessation of this pulse the glow returns to electrode a_0 which in the meantime has been re-energised by the inhibiting voltage. The counter thus reads "... 0002."

During the application of consecutive *ab* pairs the counter continues to operate in this manner, an inhibiting voltage being applied to the higher tubes so long as the glow in tube 12 is directed to a cathode representing a digit other than zero.

With the arrival of the tenth pair the glow in tube 12 is transferred to the zero cathode. The first stage now no longer develops an inhibiting voltage. Consequently the rail G_a in tube 32 is no longer re-energised negatively after the glow has passed to the rail G_b and the glow in this tube is accordingly stepped from electrode b_0 to cathode 1. The inhibiting function in respect of this pulse pair is now exercised by this stage, the inhibiting voltage being applied over channel 42 to the remaining higher stages, which accordingly still indicate zero (a_0) at the end of this pulse pair.

The next pulse pair *ab* transfers the glow in tube 12 from the zero cathode to cathode 1, with the result that this stage resumes the inhibiting function. Thus the glow in tube 32 is transferred to electrodes a_1 and b_1 by the pulses and, after the *b* pulse, returns to electrode a_1 , thereby again indicating substantially the tens digit "1." During the receipt of the next eight units to be added, the glow in tube 12 is stepped forward in the manner already described, this tube again exercising the inhibiting function. For each pulse pair the glow in tube 32 is stepped from electrode a_1 to electrode b_1 and then back to a_1 . The remaining stages operate over electrodes a_0 and b_0 as already described, the glow again coming to rest at a_0 at the cessation of each *b* pulse.

The operation of the apparatus in counting down on receipt of a pulse pair *ba*, representing a unit to be subtracted from the count, will now be described, it being assumed that before the receipt of this pair each tube indicates the number "3."

From the above description it will be realised that whereas the glow in tube 12 is directed to cathode 3 itself, the glow in each of the higher tubes is directed not to cathode 3 but to electrode a_3 . Consequently the pulse sequence *ba* has the effect in tube 12 of transferring the glow first to electrode b_2 , then electrode a_2 , and finally to cathode 2. In the remaining tubes, on the other hand, the *b* pulse transfers the glow from electrode a_3 to electrode b_3 and the ensuing *a* pulse transfers it back to electrode a_3 , to which electrode the glow remains directed on the cessation of the *a* pulse because of the inhibiting voltage from tube 12. Each of these tubes, therefore, continues to indicate the number "3."

The action is similar on receipt of the next pulse pair *ba*, which brings the reading down to "... 331."

The next pulse pair reduces the tube 12 reading to 0, thereby removing the inhibiting voltage from tube 32. The glow in tube 32 is accordingly directed to cathode 3 rather than electrode a_3 , this tube accordingly now exercising the inhibiting function in respect of the higher powers.

The next pulse pair changes the tube 12 reading to 9, thereby restoring the inhibiting function to this tube. Hence the glow in tube 32 is transferred by this pulse pair from cathode 3 to electrodes b_2 and a_2 in turn, remaining on electrode a_2 because of the inhibiting voltage. The reading of the counter is thus "... 329."

The inhibiting voltage may alternatively be applied to the guide-rail G_b . The counter is then as shown in Fig. 2 but with the connections to the G_a and G_b rails interchanged; for example, in stage 11 the rail G_a is connected to channel 21 and the rail G_b to amplifier 15. The operation is similar to that already described except that in each tube whose action is inhibited the glow comes

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to rest on a *b* electrode rather than on an *a* electrode. As this would indicate the intended cathode less clearly, since the glow would be nearer the cathode that is one higher than the appropriate one, the arrangement is less satisfactory than that first described in which the inhibiting voltage was applied to the rails G_a .

As already stated, the counter is not limited to the use of dekatron tubes. Where for example the incoming pulses represent minutes of angular measurement the counter may conveniently include a dekatron stage in which the minutes are counted up to ten followed by a hexatron (six-cathode) stage in which the ten-minute counts are added up to degrees, and finally one or more dekatron stages in which the degrees are counted. The six cathodes of the hexatron tube are considered as cathodes 0 to 5. Cathodes 1 to 5 are connected together and from their common circuit is derived an inhibiting voltage for the higher stages—those counting the degrees. The zero cathode is connected to a lead which is the equivalent of lead 26 of Fig. 2. The connections to the dekatron stages are similar to those of Fig. 2. Apart from the fact that the hexatron stage only counts up to six, the operation of this embodiment is as already described.

A dodecatron (twelve-cathode) tube may, if preferred, be used in the foregoing embodiment instead of the hexatron tube. The twelve cathodes are considered as two groups of cathodes 0 to 5, the cathodes of each group being connected exactly as in the hexatron arrangement. The operation is as before except that the dodecatron tube functions as two hexatron tubes brought into use alternately.

It will be appreciated that the operation of all the stages simultaneously by each pair of applied pulses in accordance with the invention, instead of in cascade as in previous arrangements, allows a high and accurate speed of operation which is not restricted by cumulative delays to avoid errors. Moreover the reversible action functions accurately without the need for special discriminator and gating stages and hence without the need for components additional to the actual counters and their amplifiers. Furthermore, the counter is not subjected to the attenuation losses associated with the inter-stage couplings of cascade arrangements and does not require a high-tension supply of inconveniently high value necessary for such couplings.

What we claim is:

1. A reversible multistage electronic counter for operation by pairs of sequential overlapping voltage pulses *a* and *b* in either order, each pair in the order *ab* representing a unit to be added to the count and in the order *ba* representing a unit to be subtracted from the count, including for each numerical power required a glow-discharge counter tube of the kind having a circular array of digit-representing cathodes surrounding a common anode, each pair of adjacent cathodes having between them and individual to them first and second electrodes spaced in that order in the direction of increasing the count, each tube having first and second guide-rails common to all the cathodes of the tube and connected to all the first electrodes and to all the second electrodes of the tube respectively, means for applying in a negative-going sense each *a* pulse to the first rails of all the tubes simultaneously, and each *b* pulse to the second rails of all the tubes simultaneously, and for each tube, except that for the highest power, inhibiting means, operative when the discharge of the tube is directed to any of the digit cathodes of the tube which represent digits other than zero, to inhibit the counting action of the tube of each higher power whilst the glow remains directed to that cathode.

2. A counter as claimed in claim 1 wherein each inhibiting means includes a common load for the said digit cathodes of the tube which represent digits other than zero and connections for applying the voltage developed

across said load in a negative-going sense to a like guide-rail of each of the tubes of the higher powers.

3. A counter as claimed in claim 2 wherein said like guide-rail is the first guide-rail.

4. A counter as claimed in claim 1 wherein each cathode representing a zero digit is connected to a switching circuit operable at will to carry the potential of said

cathode sufficiently negative to attract to that cathode the glow discharge of the tube.

References Cited in the file of this patent

FOREIGN PATENTS

786,166 Great Britain ----- Nov. 13, 1957

Notice of Adverse Decision in Interference

In interference No. 93,356 involving Patent No. 2,975,329, J. A. Irvine and G. M. Rendall, Electronic counters, final judgment adverse to the patentees was rendered June 22, 1964, as to claims 1 and 4.

[Official Gazette August 25, 1964.]