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R. D. THORNTON  
ELECTRONIC COUNTER

2,883,108

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2 Sheets-Sheet 2

**FIG. 4.**

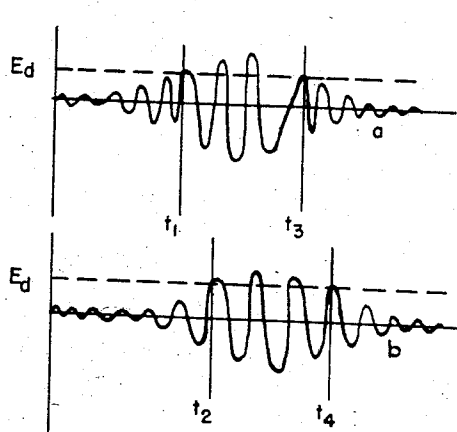
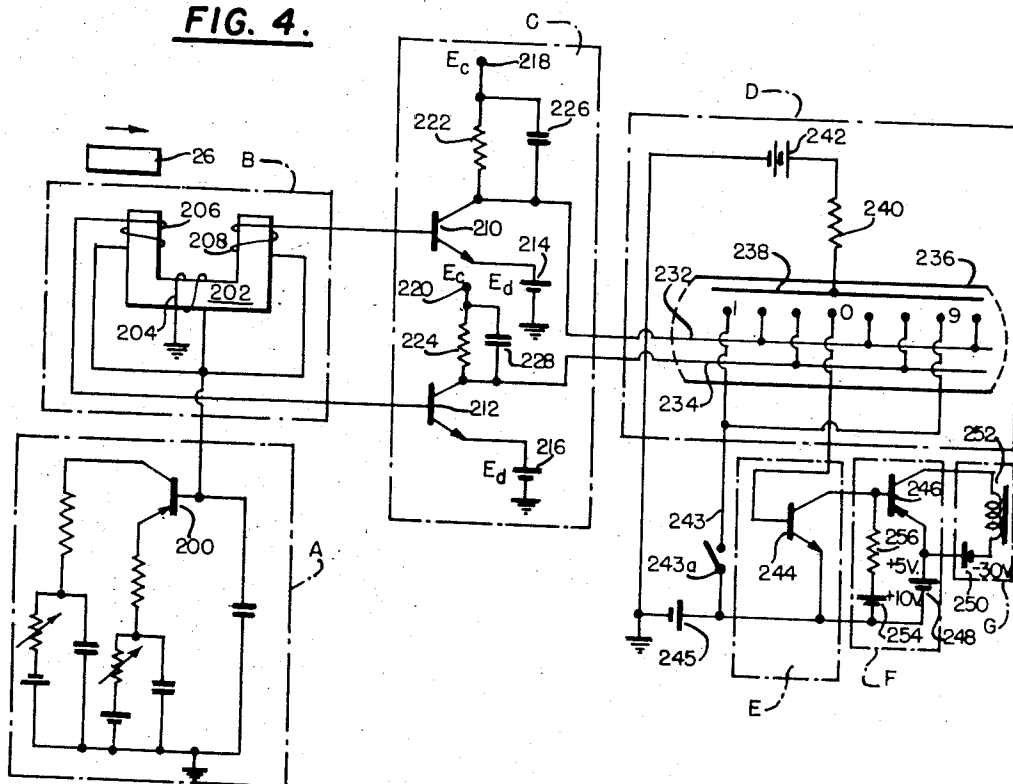


**FIG. 5.**

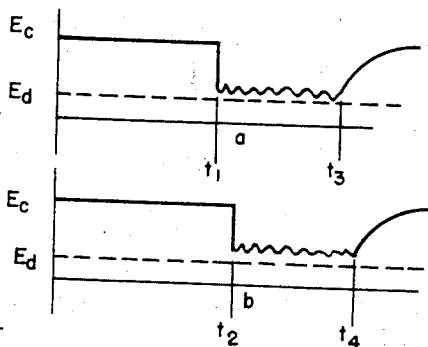


**FIG. 6.**

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2,883,108

## ELECTRONIC COUNTER

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11 Claims. (Cl. 235—92)

This invention relates to an electric counter and more particularly to systems for counting articles or revolutions of a shaft or wheel.

While devices are known in the prior art for counting parts, articles, or the revolutions of a shaft, for example, such devices are deficient in one or more respects, the most important of which is reliability. In certain applications, it is essential that the count be accurate, and that the possibility of an article being counted twice or not being counted at all be eliminated. The great majority of the prior art counter systems employ pickups (electromagnetic or photoelectric, for example) which produce a single output signal or pulse for each item counted. Such systems are subject to unreliable operation in the presence of noise, vibrations or other interference. It is possible that a momentary interruption in the normal operation of the systems may result in an item being counted twice or not at all. Where an object to be counted does not necessarily move past the pick-up in a single sweep but may move back and forth, with the usual prior art devices the object may be counted twice or more. The speed at which the object passes the pick-up is frequently critical in the prior art devices. If an object passes at too great a speed, it will not be counted, and if the object passes at too slow a speed, it may be counted twice. Moreover, in attempting to achieve accuracy, the prior art devices become unduly complicated and large in weight and size. Such systems frequently have high power requirements and long warm-up times, which make their use impractical.

Accordingly, it is a primary object of the present invention to provide counter systems which overcome the deficiencies of the prior art.

Another object of the invention is to provide counter systems which have no moving parts, except for the objects to be counted and a mechanical output, if desired.

A further object of the invention is to provide new counter systems employing a plurality of actuating signals for their operation.

An additional object of the invention is to provide unique sub-combinations of the foregoing systems, including novel pick-up devices, detector circuits, and circuits for coupling the output of the detector circuits to an indicating means.

The foregoing and other objects of the invention will become more readily apparent in the following detailed description of the invention when taken in conjunction with the accompanying drawings, wherein:

Figure 1 is a circuit diagram of one embodiment of the invention;

Figure 2 is an explanatory sectional diagram of a glow type electronic counter tube which may be employed in the systems of the invention;

Figure 3 is a circuit diagram of a modified counter system in accordance with the invention;

Figure 4 is a circuit diagram of another modified counter system in accordance with the invention;

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Figure 5 is a graphical illustration of output signals produced by the pick-up device employed in the system of Figure 4; and

Figure 6 is a graphical illustration of signals produced at the outputs of the detectors employed in the system of Figure 4 and actuated by signals of the type illustrated in Figure 5.

Briefly, the objects of the present invention are accomplished through the use of a pick-up, preferably of the electromagnetic type, which produces a pair of sequential overlapped output signals when influenced by suitable stimuli; a pair of detectors which receive the output signals from the pick-up devices; a glow discharge type electronic counter tube, which changes its condition upon the application thereto of the outputs of the detectors; an amplifier, which may include preamplifier and power output stages for receiving the output from the counter tube; and an indicating means, which may be a simple mechanical counter, arranged to be actuated by the amplifier. The pick-up is associated with or includes an oscillator, the output of which is modulated in response to the said stimuli to produce the pick-up output signals.

Referring to the drawings, the major portions of the systems of the present invention have been designated by dot-dash rectangles. The same scheme of designation has been carried out in the embodiments of Figures 1, 3 and 4, so that the similarities of the different embodiments will be evident, but it is to be understood that the inclusion in these rectangles of the various elements and components of the systems is entirely for explanatory purposes to give a general indication of function, and is in no way intended to restrict the invention to the elements or components shown or to limit the function of elements or components which may, in fact, serve to carry out the functions of more than one rectangle or to couple the output of one rectangle to the input of another. The power supplies have been illustrated in several different forms, and it is not intended that the illustration of a particular system embodiment with a particular power supply should be taken as an indication that such embodiment is limited to use with such a power supply. It will be appreciated by those skilled in the art that the proper power supply for a particular embodiment may be chosen in accordance with well known principles. With the foregoing in mind, the system of the present invention may be broken down generally into the following sub-combinations: A—a source of oscillations; B—a pick-up; C—detector circuit; D—counter tube circuit; E—preamplifier; F—power amplifier; and G—indicator. It will become apparent to those skilled in the art that certain of the sub-combinations of the system might be employed interchangeably in the various system embodiments illustrated and described, where the circumstances for their use are proper.

Referring to Figure 1, the oscillator A may assume any conventional form, and as illustrated includes a pentode 10, a power supply 12 with the usual power transformer 12a, rectifier 12b and filter elements 12c, a tuned plate network 14 including a condenser 14a and the primary 14b of a feedback transformer connected in parallel, a tuned grid network 16 including the secondary 16a of this transformer and a condenser 16b connected in series, and other conventional elements and connections including resistors 17a, 17b and condenser 19. An output transformer 13 couples the oscillations at the plate of pentode 10 to the pick-up B and detector circuit C.

The pick-up, in the form shown, comprises a substantially E-shaped magnetic core 20 of "Permalloy" or similar material. The outer legs of the core support a pair of windings 22, 24. These coils are arranged to be affected by a suitable stimulus, which, in the form shown, comprises an object 26 formed of a material, such as that

of the core, which will affect the flux path between the outer legs and the center leg of the core 20. In practice object 26 may be an article to be counted or may be constituted by a piece of magnetic, paramagnetic, or conductive material placed on a wheel or shaft, the revolutions of which are to be counted. In any event, it is intended that the object 26 shall pass in proximity to the legs of the core in succession so that the object passes one outer leg and then the other, although the direction is immaterial once established.

Each coil 22, 24 is connected to ground in series with a resistor 36, 38 which are connected at a common point to the secondary of output transformer 18. The potentials developed across coils 22, 24 are employed to charge a pair of condensers 32, 34 through detector rectifiers 28, 30. In practice the respective elements of each pair of pick-up coils, rectifiers, condensers, and resistors, preferably have substantially the same value and form identical circuits.

The potentials across condensers 32, 34 are applied to input leads 40, 42, respectively, of an electronic counter tube 43. Thus tube is preferably of the cold cathode glow discharge type, such as Sylvania type 6476, and is employed as a decade counter to scale down the output of the detector circuit C. The input leads 40 and 42 are connected, respectively, to a pair of guide electrodes 44, 46 each having a plurality of elements 44a and 46a. Tube 43 also includes a plurality of separate cathodes 48 (there being ten in a decade type counter) and an anode 50. In practice the cathodes and elements of the guide electrodes are arranged circularly about anode 50, as shown in the transverse section of Figure 2. Each adjacent pair of cathodes is separated by a pair of elements of the guide electrodes, respectively. The anode is connected to a source of plate supply at terminal 52 (for example, +300 volts with respect to ground) through a plate load resistor 54. The cathodes are connected to another terminal of the supply as indicated at 56 (which may be minus 100 volts with respect to ground). The zero cathode (the center one in Figure 1) is connected to terminal 56 through a load resistor 58, while each of the remaining cathodes of the tube is connected to terminal 56 through a load resistor 60. The connection to terminal 56 of all of the cathodes except the zero cathode may be made through a zero reset switch 66. The output of the counter tube circuit D is taken across resistors 58 and 60 and is coupled to the input of preamplifier E.

In the form shown, the preamplifier is constituted by a transistor 68 of the PNP type. The base of the transistor is connected to the zero cathode of the counter tube at its junction with resistor 58, while the emitter of the transistor is connected to the junction of the remaining cathodes with resistor 60. Another resistor 62 is connected between this junction and ground to provide the proper emitter operating voltage. The collector of the transistor is connected through a load resistor 70 to the power amplifier F, which, in the form shown, is a saturable reactor 72.

The saturable reactor includes a core 74 which supports a pair of windings 76 and 78. Winding 76 is a control winding, and winding 78 is a power winding. Windings 76 and 78 are connected in series with the secondary coils of a pair of power transformers 80, 82, the primary coils of which are connected to a source of alternating current. The secondary winding of transformer 80 is center tapped, the tap being connected to the emitter of the transistor 68, and one end of this winding is connected to the collector of the transistor through control winding 76 of the saturable reactor and the load resistor 70. In the embodiment illustrated transformer 80 produces about 30 volts across its secondary coil, half of which is sufficient to supply the transistor 68. The total secondary voltage of transformer 80 is added in series with the voltage across the secondary of transformer 82, which may be approximately 6.3 volts, and is

sufficient to power the saturable reactor as well as its load. The power supply circuit for the saturable reactor also includes a rectifier 84 and the actuating coil 86 of the indicator G, which may be shunted by a condenser 88.

The indicator G is a register of some form, which may be electric or electromechanical, and which changes its indication upon receiving an output signal from the counter tube circuit D after amplification in preamplifier E and power amplifier F. In practice the indicator is preferably a simple electromagnetically actuated mechanical counter which steps once for each impulse in coil 86. Such devices are well known and need no further elucidation.

In the operation of the system of Figure 1, the oscillator A produces continuous oscillations, which may be in the supersonic region, and these oscillations are coupled by the output transformer 18 across the coils 22 and 24 of the pick-up B. These oscillations are rectified by the detectors 28 and 30, which charge condensers 32 and 34 to a certain quiescent potential. The rectifiers are poled so that the condensers will be charged negatively with respect to ground, in the form shown.

In its initial condition, the glow discharge in the counter tube 43 (see 53 in Figure 2) is between the anode 50 and the zero cathode. The tube may be positively reset to zero, if necessary, by opening switch 66 so that all but the zero cathode will float. This will ensure that the discharge goes to the zero cathode. The negative charges on condensers 32 and 34 of the detector circuit C are made insufficient to cause the discharge to step to one of the guide electrodes under quiescent conditions. When a permeable object 26 passes between the outer leg on which coil 22 is wound and the center leg of the core 20, however, the flux through the coil is increased, which results in an increase in the reactance of the coil. This raises the potential applied to detector 30 and increases the negative potential on the condenser 34 so as to make the guide electrode 46 of the counter tube sufficiently negative to cause the glow discharge to step from the zero cathode to the adjacent element of the guide electrode. When the stimulus of the object 26 similarly affects the coil 24, a similar but time delayed increased negative potential is applied to guide electrode 44, and if these potentials overlap in time the glow discharge steps from guide electrode 46 to the adjacent element of guide electrode 44 (that element adjacent cathode 1 in Figure 1) as the output from coil 22 decreases. If the spacing between the outer legs of the core 20 is made small enough with respect to the length of the object 26, the negative pulses produced at the output of the detectors as the result of the signals in the coils 22 and 24 will overlap. Moreover, by virtue of the fact that the object 26 affects one of the coils 22, 24, before the other, the output pulses will be consecutive, beginning and ending consecutively. When these conditions are met, for each stimulus by an object 26 the glow discharge will step from a cathode to a guide electrode, then to the next guide electrode, and finally to another cathode when the pick-up ceases to produce output signals.

From the above description it will be evident that as objects 26 pass the pick-up B consecutively, the glow discharge of the counter tube 43 will be stepped from cathode to cathode in sequence until the zero cathode is reached and then will continue as before. When the glow discharge goes to the zero cathodes, the base of transistor 68 becomes more positive with respect to the emitter. The increased positive voltage on the base of the transistor is sufficient to maintain the transistor cut-off. Normally the transistor is alternately conducting and non-conducting in synchronism with the A.C. supply. Coils 76 and 78 are connected so that, in the absence of an output signal from the counter tube circuit, when rectifier 84 is non-conducting and transistor 68 is conducting, the flux in core 74 is reset to a point such that on the alternate half cycle (when rectifier 84 is conducting and transistor 68 is non-conducting) the A.C. supply

voltage is not sufficient to saturate the core and no appreciable load current is produced. However, when transistor 68 is blocked during both positive and negative half cycles by the application of a positive signal to the base of the transistor from the counter tube circuit, the saturable reactor is not reset on opposite half cycles of supply voltage, and accordingly it saturates and allows a sufficient current to pass through the actuator coil 86 of the indicating device G to change its condition. This current flows (supplied by condenser 88 on alternate half cycles) as long as the glow discharge goes to the zero cathode. The indicator mechanism is of the type which does not condition itself to step again until the potential across coil 86 is removed, however. Thus for every ten times that article 26 passes the pick-up device or for every ten articles passing the pick-up device in the same direction, the counter tube 43 will produce a single output and will step the indicating device G once. If it is desired to ascertain the unit count between the decade indication of the indicator G, the glass envelope 51 of the counter tube 43 may be calibrated so as to give a reading corresponding to the position of the glow discharge 53.

It will be evident from the foregoing that the counter tube 43 will not change its condition until output signals have been produced from both coils of the pick-up device. Thus, noise and interference which might produce a single output pulse, but not a pair of sequential overlapped pulses, would not cause the counter tube to change its condition. If the glow discharge moves only to the guide electrode element adjacent a particular cathode, it will return to the same cathode when the potential on the guide electrode element is removed. If the object 26 moves back and forth adjacent the coils 22 and 24 of the pick-up, the glow discharge of the counter tube will move off and on the guide electrode adjacent a particular cathode, but will ultimately return to the same cathode without changing the count (except where the zero cathode is involved). The interposition of the counter tube circuit D between the detector circuit C and the indicator device G provides for a very fast counting rate, for example, several thousand counts per minute. The only moving parts are the objects 26 and the mechanical counter of the indicator device G, if such a counter is employed.

Figure 3 illustrates a further embodiment of the invention. In this embodiment the oscillator A is of the transistor type and includes a PNP transistor 100, the collector of which is connected to a source of negative voltage supply at terminal 102. The pick-up of this embodiment is in the form of an H-shaped core 103. The base and emitter of the transistor are connected through a coil 104 wound on the bridge of the core. The base and the collector of the transistor are connected through a coil 106 also wound on the bridge of the core and through the power supply input impedance between terminal 102 and ground. Coils 104 and 106 are phased so as to produce oscillations. The flux induced in the core by these oscillations passes through the legs of the core on which are wound two pairs of coils, 108, 110 and 112, 114. Coils 108 and 110 are phased so that the voltages induced therein as a result of the flux variations in the associated leg are normally bucked out. The same is true with respect to coils 112 and 114. One end of coils 110 and 114 is connected to ground as indicated, and the opposite ends of coils 108 and 112 are connected to the input of the detector circuit C. The object 26, which is arranged to pass adjacent one end of the legs of the core, varies the flux relations in the core and causes an unbalance between coils 108 and 110 and between coils 112 and 114. The spacing of the legs of the core is arranged so that the output signals produced by the influence of the object 26 are consecutive and overlapping as described previously.

As the object 26 passes by and influences each of the

two sets of normally balanced output coils, a pulse of oscillations is produced from the respective sets of coils and is passed to the rectifiers 116, 118 of the detector circuit C. Each rectifier is arranged to charge a condenser 120, 122, respectively, so as to produce a negative potential thereon with respect to ground. These potentials are applied consecutively to the guide electrodes 124, 126 of a glow discharge type decade counter tube 128. The counter tube may be of the same type described in connection with Figure 1.

The embodiment of Figure 3 includes a power supply which comprises a power transformer 130, having a pair of secondary windings 132, 134, the latter of which is center tapped. These windings are connected in series as indicated. One end of winding 132 is connected to a rectifier 136 to provide the power requirements for the counter tube 128. The anode 138 of the counter tube is connected to the power supply through a load impedance 140.

Each of the cathodes of the counter tube except the zero cathode is connected as by lead 133 to the junction of windings 132 and 134 of the power transformer, which may be at a potential of approximately minus 10 volts with respect to ground, for example. This connection may include a reset switch 133a of the type indicated in Figure 1, if desired. The output of the counter tube circuit is taken from the zero cathode of the counter tube and is applied to the base of a transistor 142 which forms the preamplifier E. This transistor is of the NPN type, and the emitter is connected directly to the power supply at the junction of windings 132 and 134. The collector of the transistor is connected through a load resistor 144 to the output of rectifier 136 in the power supply. The junction of the collector and the load resistor 144 is connected to one end of the control winding 146 of a saturable reactor 145 constituting the power output stage F. The other end of the control winding 146 is connected to the output of a rectifier 148 which receives its input from the center tap of the secondary winding 134 of the power transformer. A pair of filter condensers 150 and 152 is connected as shown across the output of the secondary winding 132 and one-half of the secondary winding 134. The junction of condenser 152 and rectifier 148 may be grounded as shown.

Saturable reactor 145 also includes a power winding 154 and magnetic core 156 on which both of windings 146 and 154 are wound. The power winding 154 is connected from the lower terminal of the secondary coil 134 of the power transformer through a rectifier 158, the actuator coil 160 of the indicator device G, back to the junction of secondary coils 132 and 134. A condenser 162 is shunted across the actuator winding 160 as in Figure 1.

When the counter tube 128 has changed its condition ten times, as in Figure 1, and the glow discharge goes to the zero cathode, the current in the glow discharge is returned to the power supply through the transistor 142 by virtue of its base connection to the zero cathode and its emitter connection to the power supply. This current passes through the low input impedance of the transistor. The base of the transistor rises positively with respect to the emitter unit the transistor conducts. This causes a drop in voltage at the junction between the collector of the transistor and the load resistor 144 and consequently across the control winding 146. When the transistor is non-conducting, the current through winding 146 produces a flux which prevents the core from being driven into saturation. Accordingly, the current through actuator coil 160 of the indicator G is at a low level. However, when the transistor conducts, the voltage across core 156 does not reset the flux, thereby allowing a large current to pass through actuator coil 160.

The operation of the embodiment of Figure 3, while differing from that of Figure 1 in certain respects, as just described, is essentially the same, since a pair of output signals from the pick-up B causes the counter tube cir-

cuit D to step from one cathode to the next, and after ten steps of the counter tube, the indicator G is stepped once. The circuit of Figure 3 is simplified, however, and does offer certain advantages over that of Figure 1. In Figure 3 there is no need to buck out large quiescent voltages developed in the pick-up circuit, and accordingly there is no need to raise the potential of the cathodes of the counter tube to a relatively high level above ground. The use of an NPN type transistor in the preamplifier E allows the return of the zero cathode of the counter tube to the power supply to be made directly through the transistor. Moreover, the use of a transistor oscillator in combination with the type of pick-up described and illustrated makes the overall size of these components so small that they can be made as a single compact unit. It will then be unnecessary to transmit the carrier frequency any appreciable distance, and very long leads may be used between the pick-up and the remainder of the system without difficulty.

The embodiment of Figure 4 offers further advantages. In this embodiment the oscillator A is a conventional transistor type and includes a transistor 200 which may be connected in a negative impedance type circuit, for example. Such circuits are well known and need not be described in more detail. The output of this oscillator is coupled to the core 202 of the pick-up device B through its tank coil 204. The core is in the form of a U, with the coil 204 wound on the bight thereof. The output of the oscillator is also coupled to a pair of coils 206, 208, wound, respectively, on the legs of the core. One end of each coil 206, 208 is connected to the input of the detector circuit C.

The detector circuit comprises a pair of transistors of the NPN type designated 210, 212, respectively. The base of each transistor is connected to one end of the associated coil 206 or 208, and the emitter of each transistor is connected to ground through a source of reverse bias 214, 216. The potential of these bias sources may be designated  $E_d$ . The collector of each transistor is connected to a positive supply at terminals 218, 220, respectively. The potential of these supplies may be designated  $E_c$ . Each transistor has a plate load resistor 222, 224 and a condenser 226, 228 shunted thereacross.

The arrangement of the coils 204, 206 and 208 is such that the potentials in the coils 206 and 208 created by the currents flowing therethrough from the oscillator to ground through the transistors 210 and 212 are bucked out by the potential produced across the respective coils as the result of the flux variations in the core 202 induced therein by the coil 204. Thus under quiescent conditions, no output signals are applied to transistors.

Transistors 210 and 212 serve as both detectors and amplifiers. The bias  $E_d$  is sufficient to maintain the transistors non-conducting in the absence of a large enough input signal of opposite polarity. When the object 26 moves near the coil 206, the quiescent flux relationship will be unbalanced, and an output signal will be applied to the base of transistor 212. This signal will assume the form indicated in Figure 5a. When the output signal reaches an amplitude sufficient to exceed the level  $E_d$  of the bias source 216 in the reverse direction, the transistor will conduct. Similarly, at a slightly later time, an output signal will be obtained from coil 208 as indicated in Figure 5b. These signals are consecutive and overlapping. The level of the potential at the collectors of the transistors 210 and 212 is illustrated in Figure 6 both in the absence of and under the influence of a signal. Prior to time  $t_1$  the potential at the collector of transistor 212 is at the supply level  $E_c$ . When the output signal from the pick-up exceeds the bias level  $E_d$  at time  $t_1$  (Fig. 5) the transistor conducts, and the drop across plate load resistor 224 causes the output potential of transistor 212 to drop as indicated in Figure 6a. When the transistor conducts, condenser 228 is charged to the potential across resistor 224. A similar phenom-

enon occurs at the output of transistor 210 at time  $t_2$ . These output potentials are applied, respectively, to the guide electrodes 232 and 234 of a counter tube 236 of the type previously described.

The anode 238 of the counter tube is connected through a load impedance 240 to a source of D.C. 242, the negative terminal of which is connected to ground. The cathodes 1 through 9 of the counter tube are connected to ground through a positive bias source 245. The connection 243 of these cathodes to ground may include a reset switch 243a, as described previously.

When the potential of the respective guide electrodes drops to the level indicated in Figure 6, which is less positive than the bias from source 245, the glow discharge steps from cathode to cathode in the manner described previously. When the glow discharge rests on the zero cathode, an output is provided for coupling to the input of a preamplifier E.

In this instance the preamplifier is in the form of a transistor of the NPN type with the base connected directly to the zero cathode and the emitter connected to the bias source 245. The collector of transistor 244 is directly connected to the base of a power transistor 246, which forms the power amplifier F. A small battery or D.C. supply 248 is connected between the emitter of transistor 246 and the emitter of transistor 244, while a larger battery 250 is connected between the emitter of transistor 246 and the collector through the actuator coil 252 of the indicator device G. Another battery 254 is connected in series with a resistor 256 across the emitter and collector of transistor 244. This battery ensures that the power transistor is cut off even if a small leakage current flows through the zero cathode.

When the glow discharge goes to the zero cathode of the counter tube, the base of transistor 244 is driven more positive with respect to the emitter, and the transistor conducts. When this happens, the potential at the collector of the transistor becomes more negative, and this negative potential is applied to the base of transistor 246. When the base of this transistor is driven more negative, the transistor conducts and a current flows through the actuator coil 252.

The similarity of the manner of operation of the embodiment of Figure 4 with respect to the previously described embodiments will be evident. The differences in the circuits are believed to be significant, however. Since transistor circuits are used throughout in the embodiment of Figure 4, except for the glow tube counter, the power requirements are relatively low. Moreover, the circuit of this figure may be constructed in a very compact form. The relatively heavy magnetic amplifier has been eliminated, the core of the pick-up simplified, and the detector circuit arranged to amplify so as to increase the level of the signal applied to the counter tube. The latter feature is important where a long distance exists between the pick-up unit and the remainder of the system.

While what are now believed to be preferred embodiments of the system and subcombinations of the invention have been shown and described, it will be apparent to those skilled in the art that modifications may be made in such embodiments without departing from the principles and spirit of the invention. The foregoing embodiments are, therefore, intended to be exemplary rather than restrictive, and those modifications which fall within the meaning and range of equivalency of the appended claims are included therein.

What I claim as my invention is:

1. In a system of the type described, pick-up means having a pair of outputs at which signals are generated sequentially in response to the application of a stimulus to said pick-up means, indicator means for registering stimuli applied to said pick-up means, means coupling said pick-up means and said indicator means for actuating said indicator means from said pick-up means only upon the generation of a predetermined number of pairs

of said signals, said pick-up means comprising a pair of coils arranged for application of said stimulus thereto sequentially, said coils being coupled to said outputs, respectively, an oscillator, and means coupling said oscillator to said coils, said means for coupling said coils and said oscillator comprising means for balancing out from said coils the oscillations from said oscillator in the absence of said stimuli.

2. In a system of the type described, pick-up means having a pair of outputs at which signals are generated sequentially in response to the application of a stimulus to said pick-up means, indicator means for registering stimuli applied to said pick-up means, and means coupling said pick-up means and said indicator means for actuating said indicator means from said pick-up means only upon the generation of a predetermined number of pairs of said signals, said coupling means comprising an electronic counter device of the type having a plurality of output electrodes and guide means for causing an output signal to shift between pairs of said electrodes in response to the application to said guide means of sequentially generated overlapping signals, the sequentially generated signals from said pick-up means being overlapping.

3. In a system of the type described, pick-up means having a pair of outputs at which signals are generated sequentially in response to the application of a stimulus to said pick-up means, indicator means for registering stimuli applied to said pick-up means, and means coupling said pick-up means and said indicator means for actuating said indicator means from said pick-up means only upon the generation of a predetermined number of pairs of said signals, said coupling means comprising a pair of detectors coupled, respectively, to said outputs.

4. The system of claim 3, said detectors comprising condensers that are charged by said signals.

5. The system of claim 3, said detectors comprising a pair of amplifiers that are cut off in the absence of said signals.

6. In the system of claim 3, means for biasing said detectors to cut-off in the absence of said stimuli.

7. In the system of claim 3, said detectors producing output potentials in the absence of said stimuli, and means for changing said potentials in response to said stimuli to produce said output signals.

8. A counter system comprising a source of oscillations, means modulating said oscillations for producing a pair of sequential output signals in response to each of stimuli to be counted, indicator means, and means actuating said indicator means to change its indication once in response only to a predetermined number of pairs of said output signals, said actuating means comprising a glow discharge electronic counter tube of the type requiring the application of a pair of sequential signals thereto to change its operating condition, said actuating means further comprising amplifier means cou-

pled between said tube and said indicating means, said amplifier means comprising a saturable reactor, the saturation of which is controlled by said tube.

9. A counter system comprising a source of oscillations, means modulating said oscillations for producing a pair of sequential output signals in response to each of stimuli to be counted, indicator means, and means actuating said indicator means to change its indication once in response only to a predetermined number of pairs of said output signals, said actuating means comprising a glow discharge electronic counter tube of the type requiring the application of a pair of sequential signals thereto to change its operating condition, said actuating means further comprising amplifier means coupled between said tube and said indicating means, said amplifier means comprising a transistor, said tube having an output electrode connected to a power supply for said tube through said transistor, said transistor having a low impedance to current flowing between said electrode and said supply.

10. A counter system comprising a source of oscillations, means modulating said oscillations for producing a pair of sequential output signals in response to each of stimuli to be counted, indicator means, and means actuating said indicator means to change its indication once in response only to a predetermined number of pairs of said output signals, said actuating means comprising a pair of detectors adapted to receive said signals, respectively, and means for preventing output signals from said detectors in the absence of said sequential signals.

11. In a system of the type described, pick-up means having a pair of outputs at which signals are generated sequentially in response to the application of a single stimulus to said pick-up means, indicator means for registering stimuli applied to said pick-up means, and means coupling said pick-up means and said indicator means for actuating said indicator means from said pick-up means only upon the generation of a predetermined number of signals at said outputs sequentially, said pick-up means comprising a pair of coils arranged for application of said stimulus thereto sequentially, said coils being coupled to said outputs, respectively, an oscillator, and means coupling said oscillator to said coils, said pick-up means further comprising a magnetic core to which said coils and said oscillator are coupled, said core having a pair of legs carrying said coils, respectively, said stimulus comprising means for varying the flux through said legs.

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**UNITED STATES PATENT OFFICE**  
**CERTIFICATE OF CORRECTION**

Patent No. 2,883,108

April 21, 1959

Richard D. Thornton

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 61, for "unit" read -- until ---; same line for "conduits" read -- conducts ---.

Signed and sealed this 10th day of May 1960.

(SEAL)

Attest:

KARL H. AXLINE  
Attesting Officer

ROBERT C. WATSON  
Commissioner of Patents

**UNITED STATES PATENT OFFICE**  
**CERTIFICATE OF CORRECTION**

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Signed and sealed this 10th day of May 1960.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

**ROBERT C. WATSON**  
Commissioner of Patents