Oct. 10, 1961 C. F. STRANDBERG 3,003,691

METHOD AND APPARATUS FOR COUNTING IMPULSES

Filed Nov. 8, 1957 3 Sheets-Sheet 1

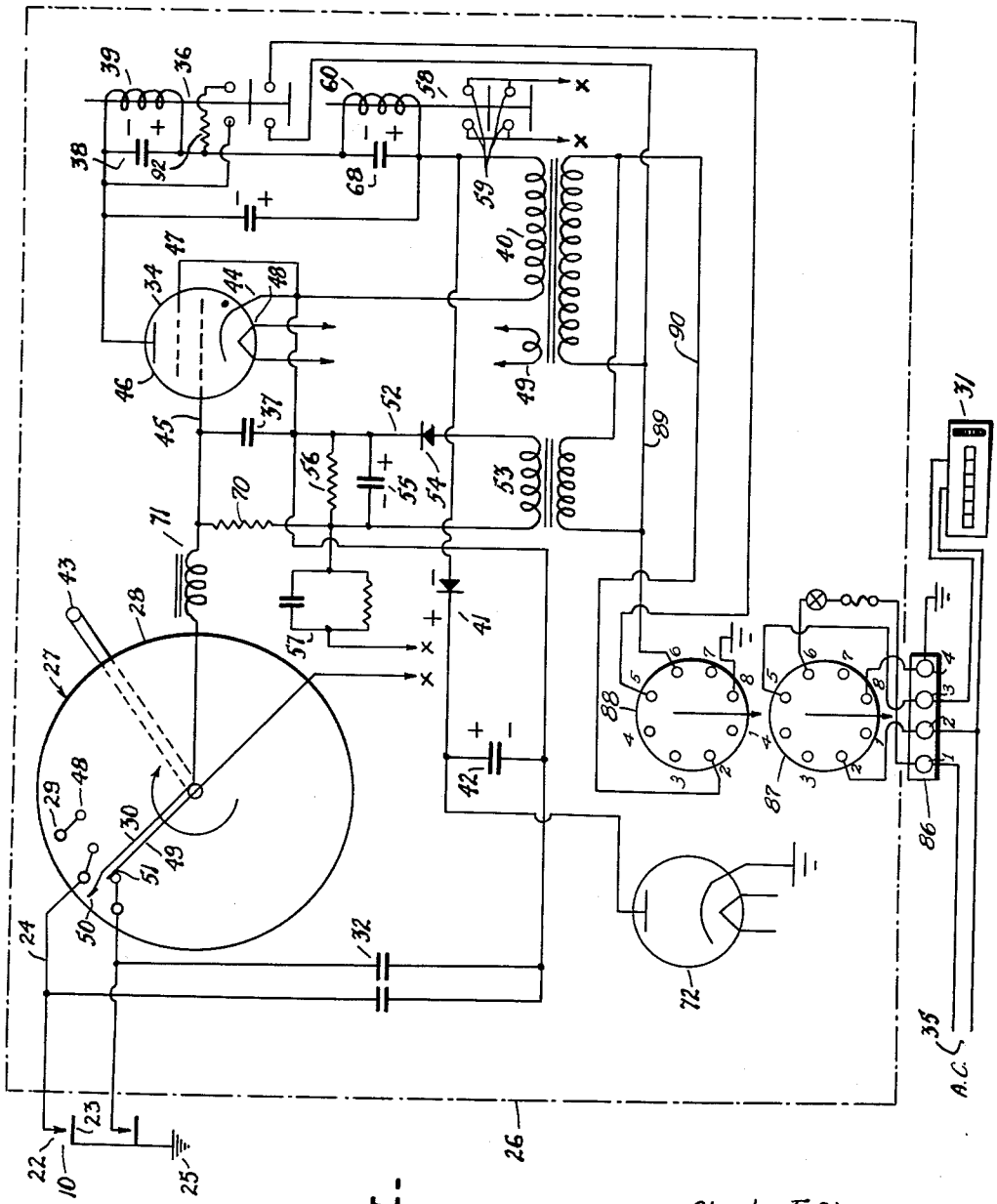

FIG. 1.

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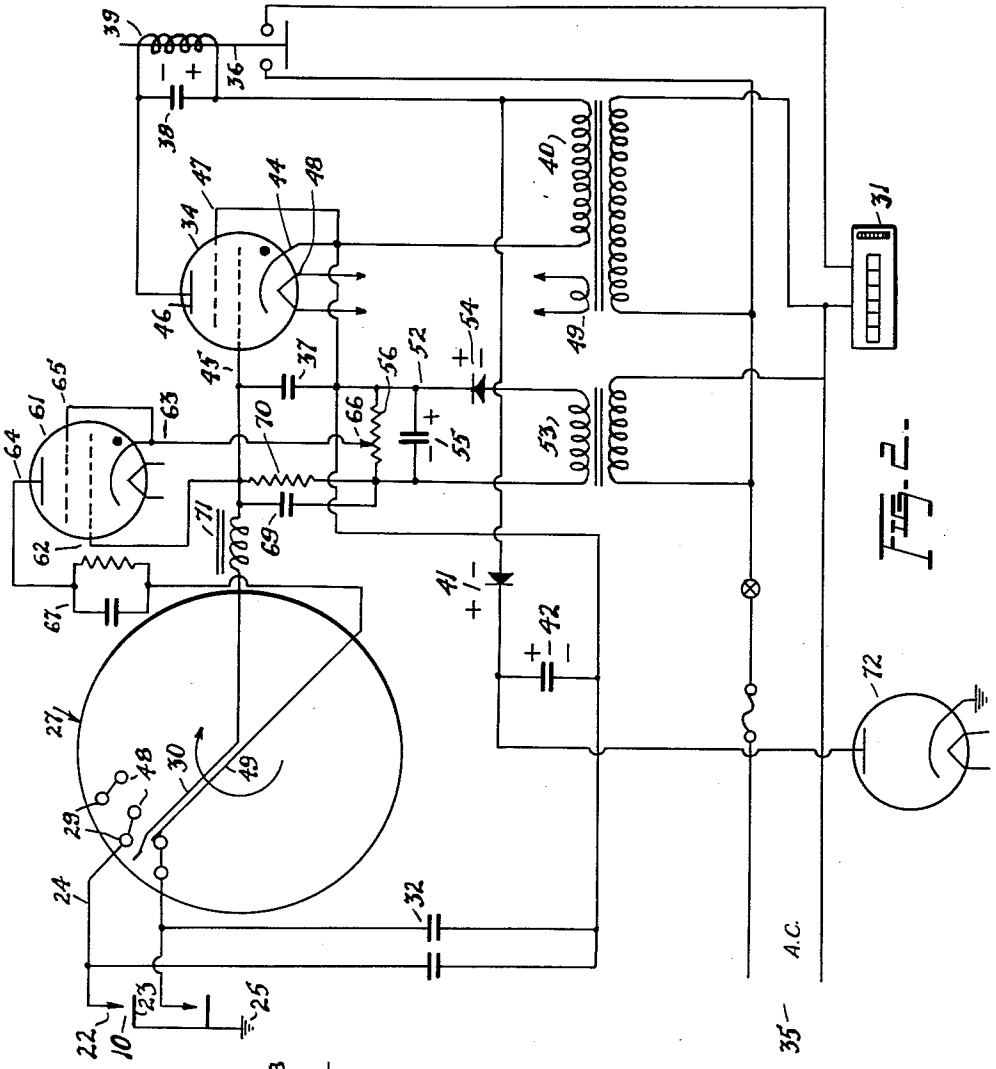

FIG. 2.

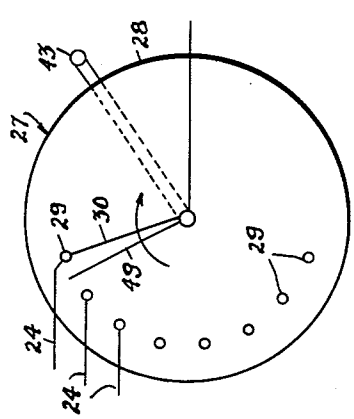

FIG. 4.

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METHOD AND APPARATUS FOR COUNTING IMPULSES

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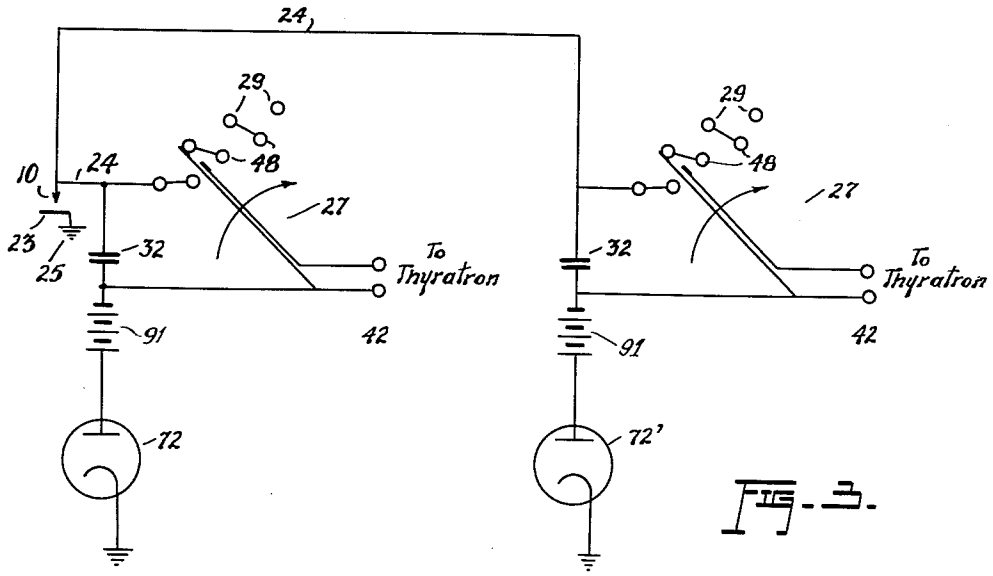

FIG. 3.

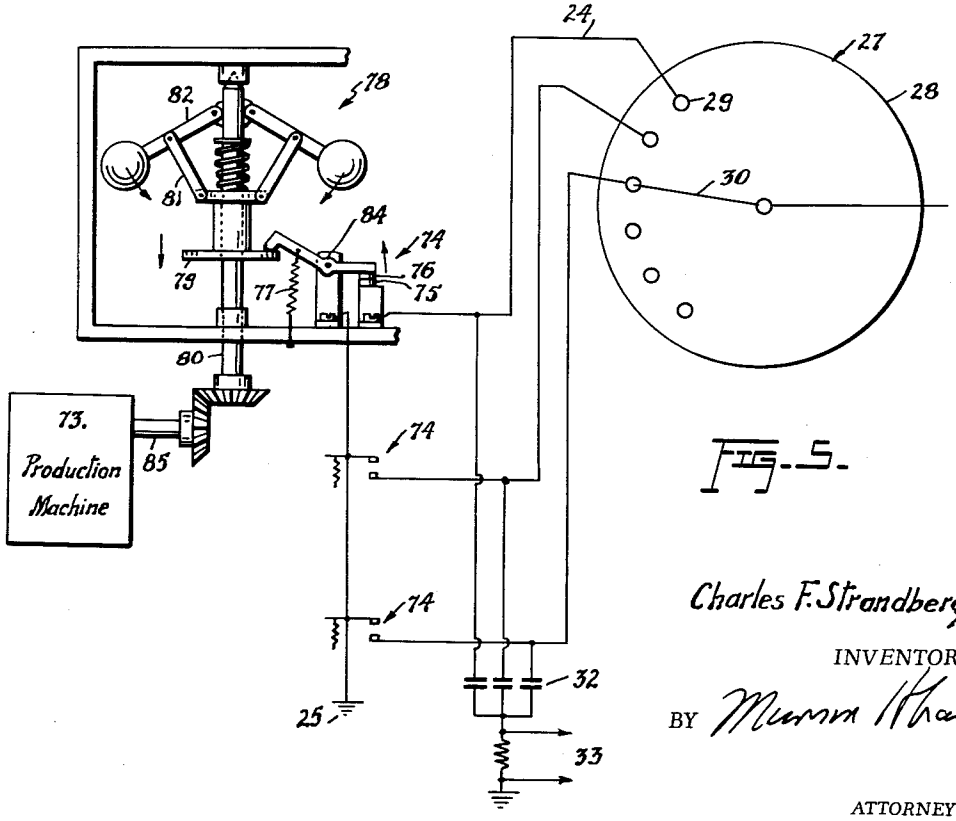

FIG. 5.

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3,003,691

METHOD AND APPARATUS FOR COUNTING IMPULSES

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Filed Nov. 8, 1957, Ser. No. 695,358
10 Claims. (Cl. 235—92)

This invention comprises a method and an apparatus for counting impulses from a plurality of random sources without error and includes a circuit provision which permits two or more such counters to be connected to one machine-located, impulse switch.

In my prior application Serial No. 572,902 now Patent No. 2,831,635 of which this application is a continuation in part filed March 21, 1956, entiled Random Information Counting Method and Apparatus, I have described apparatus which receives impulses at random and arranges them sequentially for counting purposes. The apparatus therein described comprises a plurality of impulse switches and a rotary sampling switch including a plurality of contacts in circuit with the respective impulse switches. The rotor of the sampling switch sweeps each contact sequentially and applies the impulse stored thereon to the grid of an impulse receiving tube. The tube on receiving an impulse at its grid fires and activates a counter actuating circuit. Important elements of this apparatus are memory capacitors in circuit with each impulse switch and its respective contact on the rotary sampling switch. Impulses generated at random by the plurality of impulse switches are stored in the memory capacitors until such time that they are received by the sampling rotor.

With references to application Serial No. 572,902 now Patent No. 2,831,635 of which this application is a continuation in part, it has been found that positive error of the order of one part in ten thousand is possible when an impulse is received at the instant the rotor arm is departing from the particular contact being energized. The old method employs two means for limiting this error: (*a*) use of short-duration pulse making switches, and (*b*) a resistance-capacitance network intended to delay the appearance of the signal to the impulse receiving tube for counting until erase or discharge has been accomplished.

The new method provides for positive erase by feeding back to each contact and its associated capacitor a voltage which is negative with respect to that appearing across the memory capacitor. In order not to erase charges which have not been counted, the feedback device is made to operate only when a count has been registered.

Another object of this invention is to provide a unidirectional electron valve in the memory capacitor charging path to ground in order to permit two or more counters to receive impulses from the same impulse switch without interaction between the two counters.

The method disclosed in application Serial No. 572,902, now Patent No. 2,831,635, does not allow the use of two or more counters connected to the same impulse switch, which imposes practical limitations upon a system of counters.

An example of the need for multiple connection of counters is in a textile weave room, where the object is to count picks from groups of forty or fifty looms for worker pay determination and simultaneously to count picks from certain looms in several groups for determination of production by style of cloth being woven. The lines from the looms terminate in a panel board, from which selected machines are connected to counters by means of patch cords similar to those used by telephone operators.

Other advantages in being able to connect two or more counters to one machine-located, impulse switch include registration of inventory simultaneous with production counting and measurements of machine speed and efficiency without interference with counting.

Another object of this improved apparatus is to further the degree of integration of the impulse applied to the impulse receiving tube by inserting an induction coil in the input impedance network.

Other advantages and features of the invention will become apparent from the following description taken in conjunction with the accompanying drawing, wherein like characters of reference are used to designate like parts, and wherein:

FIGURE 1 is a diagrammatic illustration of the counting apparatus in accordance with the invention;

FIGURE 2 is a diagrammatic illustration of a modification of the counting apparatus in accordance with the invention; and

FIGURE 3 is a simplified circuit diagram showing only those components affected in two counters connected to one impulse switch.

FIGURE 4 is a schematic detail view of a modification of the rotary sample switch used in accordance with the invention.

FIGURE 5 is a partial circuit drawing showing a modified form of my counting apparatus used for counting machine-hours of production from a group of machines.

In accordance with the invention each information source is provided with an electric impulse switch designated generally by reference numeral **10**. One contact **23** of each impulse switch is connected to a common ground **25**. A second contact **22** is connected by conductor **24** to a remote control panel **26** at which there is provided a rotary sampling switch **27**. The latter comprises a plate **28** having a plurality of circumferentially spaced contacts or segments **29** theron, the number of these contacts or segments corresponding to the number of information sources to be counted. The plate **28** also carries a rotor arm **30** which is suitably driven at a fixed rate so as to successively engage the contacts **29** each once during a certain period.

The wires or conductors **24** from the several switches **10** are connected to the respective contacts **29** of the sampling switch **27**, it being noted for simplicity of illustration in the accompanying FIGURE 1, only several of such connections have been shown.

The sampling switch **27** is adapted to retain an electrical impulse on any one of the contacts **29** until such impulse is picked up by the rotor arm **30** and transmitted by means hereinafter described to a suitable counter **31**. Moreover, after the impulse is picked up by the rotor arm, the segment or contact **29** must be free of the impulse. Finally, the rotor arm **30** must make contact with all the segments in less time than can possibly exist between two successive impulses applied to any particular segment.

In order to satisfy the above conditions, a plurality of memory capacitors **32** are provided in circuit with the respective conductors **24** leading to the respective segments **29** and a common direct current source. The direct current source may comprise any conventional power supply but has been shown by way of illustration to consist of a rectifier network comprising a transformer **40**, a rectifier element **41**, and a filtering capacitor **42**. Alternating current is supplied to the primary of transformer **40** from a suitable source **35** by way of a pair of conductors connected to terminals **1** and **2** of terminal board **86**, contacts **2** and **6** of plug connector **87**, and corresponding contacts **2** and **6** of jack **88** mounted on control panel **26**. Conductors **89** and **90** connect the

primaries of transformers 40, 49 and 53 to the current source 35 through the jack contacts 2 and 6. The terminal board 86 and the plug and jack connectors are shown merely to illustrate the use of my impulse counting apparatus at a point remote from the counting register 31. FIGURE 2 discloses the primaries of transformers 40, 49 and 53 connected to the alternating current source 35 without going through a plug and jack connector. The polarity of the direct current supply is such that the capacitors 32 are charged when the respective switches 10 are momentarily closed thereby making the segments 29 positive with respect to the cathode 44 of a suitable impulse receiving tube 34. The charge path for each of the memory capacitors 32 includes the direct current power supply (comprising transformer 40, rectifier 41 and capacitor 42) cathode grounded diode 72 and the impulse switch 10 associated with a particular memory capacitor.

The impulse receiving tube 34 may be a gas filled tetrode as illustrated, comprising in addition to the cathode 44 a control grid 45, a plate 46, a screen grid 47, and a filament 48. The filament is supplied with alternating current by transformer 49. The plate is supplied with potential from across transformer 40. A bias voltage is applied to the grid 45 of tube 34 through resistor 70 from a negative voltage source 52 subsequently to be described.

The rotor arm 30 is rotated at a constant speed by a suitable drive mechanism 43. The speed at which the rotor is driven is selected to be greater than the rate of occurrence of the impulses so that the rotor arm 30 contacts all the segments 29 in less time than exists between two successive impulses applied to any given segment.

When the rotor arm 30 picks up an impulse from any one of the segments 29, the grid 45 of the tube 34 is rendered positive, causing the tube to conduct. The counter 31 is in circuit with a source of alternating current 35 and with the tube 34 through a relay 36, the closing of the latter being arranged to actuate the counter each time positive potential is delivered to the grid of the tube 34. A damping capacitor 38 is placed across the relay coil 39 to improve the relay response.

Although the response of the relay 36 is improved by the capacitor 38 for the reason that the voltage applied to it is a pulsating D.C. voltage, the capacitor 38 acts to lengthen the relay closure time, which is not desirable. A second set of contacts is provided on relay 36 for the purpose of permitting capacitor 38 to discharge rapidly through a current limiting resistor 92 at the instant the relay is energized thus satisfactorily reducing the closure time of relay 36.

The apparatus heretofore described except for diode 72 in the charge path of capacitor 32 is essentially common to apparatus described in my prior application Serial No. 572,902, now Patent No. 2,831,635 and to the random counting apparatus of the present invention. The improvements provided by this invention will now be described in detail.

Positive erase of any voltage which may remain on any one of the contacts 29 of the sampling switch 27 is effected by applying to each contact and its associated capacitor 32 a voltage which is negative with respect to the voltage appearing across the capacitor.

With reference to FIGURE 1, the sampling switch 27 contains two sets of connected contacts or segments 29, 48 and two rotors 30, 49, driven together. FIGURE 1 shows the outer set of primary contacts 29 sampled by the counter rotor 30 and the inner set of secondary contacts sampled by the erase rotor 49.

The erase rotor arm 49 is made shorter than counter rotor arm 30 and the contact points 50, 51 on rotor arms 30 and 49 respectively are in radial alignment with the center of rotation of the rotor arms. Each secondary contact 48 is positioned inwardly of the associated contact 29 relative to the center of plate 28 and forwardly of contact 29 relative to the direction of rotation of the rotor arms. This particular arrangement of the contacts is provided in order that the contacts 48 exposed to rotor 49 are sampled later than those exposed to the counter rotor 30.

However, the invention which is to accomplish the erase function is not limited by the particular physical arrangement of the contact segments. For instance, as illustrated in FIGURE 4, the inner set of contacts 48 can be avoided completely if the two rotors blades are the same length and the erase rotor blade 49 is made to follow directly behind the path of the counter rotor blade 30.

The negative erase voltage may be taken across any suitable D.C. source 52 but is shown in FIGURE 1 to be taken across an alternating current rectifier network comprising an A.C. current source 35 transformer 53, rectifier 54, smoothing capacitor 55 and output resistor 56. Capacitor 55 is selected of such value that it is capable of sustaining a constant D.C. erase voltage across it, substantially not influenced by changing load conditions. From the direct current source the erase voltage is conducted by way of impedance network 57, the contacts 59 of erase relay 58 and erase rotor arm 49. The coil 60 of relay 58 is in the plate circuit of impulse receiving tube 34. The erase relay 58 therefore operates only when tube 34 conducts and a count is received by counter 31. Two sets of contacts are shown on relay 58 merely to indicate the usage of two identical relay types, 36 and 58. One set of contacts would perform satisfactorily for the purpose of this invention.

Assume that a count is received and registered, automatically making operative the erase device by applying a voltage to the erase rotor which is negative with respect to that which caused the counter to operate. The erase rotor comes in contact with the segment or contact from which the count has been received and applies a negative pulse, thus rapidly discharging the associated capacitor 32.

Unless a count is received in time to be counted it will not be erased, since the erase device depends upon registration of a count to operate.

The means for erasing as has been described and is shown in FIGURE 1 makes use of an additional set of relay contacts 59 operated by a relay coil 60 in the plate circuit of the tube 34. Since the tube conducts only at receipt of a count, the relay contacts 59 close at this time and apply the negative potential to the contact 48 and capacitor 32.

Another suitable means for accomplishing erase switching is shown in FIGURE 2. A second switching tube 61, in this case a gas controlled tetrode, is connected so as to deliver a negative voltage to the capacitor 32 at the time of registration, thus eliminating the need for relay contacts and permitting operation at higher speed.

Tube 61 comprises a control grid 62 connected to control grid 45 of tube 34, a cathode 63, plate 64, and cathode connected screen grid 65. Since the control grids 62 and 45 are connected and suitable cathode bias for tube 61 is obtained by a tap 66 off the output resistor 56 of rectifier network 52, tube 61 will not fire until such time that a count fires tube 34. When tube 61 fires a negative voltage from the plate 64 is applied through conductors including impedance network 67 to the erase rotor 49. Plate current source for tube 61 is the residual positive voltage across memory capacitor 32 in series with a fixed voltage of the same polarity existing across the portion of resistor 56 shown to the right of the tap 66.

Both circuits are damped so as to time the application of the negative voltage so that it is present only long enough for the erase rotor 49 to reach the contact 48. Damping capacitors 68 and 69 respectively are shown across the relay coil 60 in FIGURE 1 and across the input resistance 70 in FIGURE 2.

As shown in FIGURES 1 and 2, the improved apparatus substitutes a coil 71 for the resistor in the tube input

resistance-capacitance network illustrated in FIGURE 1 of my application S.N. 572, 902 now Patent No. 2,831,635 of which this application is a continuation in part to further the degree of integration.

With reference to FIGURES 1 and 2, a uni-directional valve, in this instance a vacuum diode **72** has been inserted in the memory capacitor charging path to ground in order to permit two counters to receive impulses from the same impulse switch without interaction between the two counters. In some installations it may be desirable to connect one or more of my counting apparatus (hereinafter called a counting unit in order to indicate a complete counting apparatus) to the same machine located impulse generating switches **10**. When so connected the switches **10** will be component parts of plural counting units. Interaction between the plural counting units would prevent their proper operation of some means were not provided to counteract the interaction. These means provided are the uni-directional valves **72** shown in FIGURES 1 and 2. The use of these valves in the charge paths of memory capacitors **32** is not required when only one counting unit is connected to the impulse switches **10**. They are required to prevent interaction when plural units are connected to the same impulse switches.

FIGURE 3 is a simplified circuit diagram showing only those components affected in two counters connected to one impulse switch **10**.

The addition of the vacuum tube diode, **72**, prevents the memory capacitor **32** contained in one counter from being discharged by the discharging of memory capacitor **32** contained in the other counter. In order for current to flow in the loop from one memory capacitor contained in one counter to one memory capacitor contained in the other counter, it must pass through both diodes **72, 72'**, which is made impossible regardless of direction of flow, since one diode blocks current flow one way while the other diode blocks it the other. The diodes are, however arranged in the circuit so as to permit charging of the memory capacitors **32** at the time of momentary closure of the machine-located, impulse switch **10**. A battery **91** has been shown in FIGURE 3 as representative of a direct current source which may be the rectified alternating current power supply shown in FIGURES 1 and 2. The charge path for the capacitors **32** with the exception of the substitution of the battery power supply **91** is the same as that described for FIGURE 1. The only possible discharge path available for the memory capacitors is through the rotary switch **27**.

Although the apparatus of this invention has been described relating it to its use for counting information produced at random, it may be modified for use to count production time or machine hours of production. FIGURE 5 illustrates apparatus with which machine hours of production can be counted by substituting for switch **10** switches **74** which are closed while production machines **73** are operating and which are open when the machines are idle. Only such parts of the circuits of my counting apparatus which are necessary to show the connection of the switches **74** are shown in FIGURE 5. Otherwise the counting circuits may be the same as shown in FIGURE 1 of my prior application Serial No. 572,902 now Patent No. 2,831,635 of which this application is a continuation-in-part, or in FIGURES 1 and 2 of this application. The switches **74** may be of any type which function as described above, but for purposes of illustration a centrifugal switch having a fixed contact **75** and a pivoted contact arm **76** has been shown. Contact arm **76** is biased to an open position by spring **77**, when the associated machine **73** is idle. Contact arm **76** is pivoted to a closed position by means of a sliding collar **79** slidably mounted on shaft **80** of centrifugal operator **78**. Pivoted links **81** connect collar **79** to flyweight arms **82**. Flyweight arms **82** are pivotally connected to shaft **80** and when rotated thereby are caused by centrifugal action to pivot outwardly and transmit through links **81** sliding action to the collar **79**. Collar **79** engages a ball-bearing on contact arm **76** and pivots the contact arm about pivot point **84** to close switch **74**. Shaft **80** of the centrifugal operator is suitably driven by an operating shaft **85** of machine **73**.

The centrifugal switch and operator described above are generally described in U.S. Patent No. 1,201,564, issued to P. U. Dancel October 17, 1916. The particular centrifugal switch shown in FIGURE 5 is merely illustrative of one of many types of switches which are actuated by movement of a shaft and suitable for use with this invention.

The only necessary modification of the apparatus is the substitution for impulse switch **10** of switch **74** which functions as above described. Contacts **76** of switches **74**, associated with production machines **73**, are connected to a common ground. Contacts **75** are connected to respective contacts **29** of sampling switch **27** and to capacitors **32**. The rotor of sample switch **27** is driven at a constant speed, preferably at some convenient hourly ratio such as 100 revolutions per hour, if a sampling speed of 100 revolutions per hour is selected.

The function of my production time counter will now be described. Assume that all of the machines whose operations are sampled by sample switch **27** are operating. The switches **74** will be closed. Each time sample rotor **30** completes a revolution it has engaged each of the contacts **29** and a count has been recorded for each operating machine. Each count is registered as one one-hundredth of a machine hour. In one hours's time the counting apparatus will have counted one machine hour of production for each machine operating. If there are 60 machines associated with the sample switch and the machines have operated continuously for one hour of time, the total count will be 60.00 machine hours of production. If one machine is idle for a part of the hour, switch **74** will open and no count will be recorded for the idle machine during each one one-hundredth of an hour that the machine is idle. Assume that one machine is idle for one-half hour, then the total production time count for all of the machines will be 59.50 machine hours.

While in the foregoing there have been described and shown the preferred embodiment of the invention, various modifications may become apparent to those skilled in the art to which the invention relates. Accordingly, it is not desired to limit the invention to this disclosure and various modifications may be resorted to, such as may lie within the spirit and scope of the appended claims.

I claim:

1. In data sampling apparatus, the combination of a plurality of independent data impulse storing circuits, a source of erase potential, a rotary sample switch including a plurality of contacts in circuit with the respective data impulse storing circuits, a sample rotor engageable individually and successively with said contacts, and an erase rotor engageable individually and successively with said contacts, said erase rotor being positioned with respect to said sample rotor so that the erase rotor engages a particular one of said contacts immediately after said sample rotor has left said particular contact, and so that said erase rotor disengages said particular contact prior to the instant when said sample rotor engages the next succeeding contact, and switching means for intermittently making connection between said erase potential and the erase rotor each time an impulse is taken from said contacts by said sample rotor.

2. In data sampling apparatus, the combination of a plurality of independent data impulse storing circuits, a source of erase potential, a rotary sample switch including a plurality of primary contacts in circuit with the respective data impulse storing circuits, a plurality of secondary contacts connected respectively to said pri-

mary contacts, a sample rotor engageable individually and successively with said primary contacts, and an erase rotor engageable individually and successively with said secondary contacts, said erase rotor being positioned with respect to said sample rotor so that the erase rotor engages the secondary contact which is connected to a particular one of said primary contacts immediately after said sample rotor has left said particular primary contact, and so that said erase rotor disengages the secondary contact which is connected to the particular primary contact prior to the instant when said sample rotor engages the next succeeding primary contact, and switching means for intermittently making connection between said erase potential and the erase rotor each time an impulse is taken from said contacts by said sample rotor.

3. In counting apparatus, the combination of a plurality of independent data impulse storing circuits, a source of erase potential, a rotary sample switch including a plurality of contacts in circuit with the respective data impulse storing circuits, a sample rotor engageable individually and successively with said contacts, an erase rotor which applies said erase potential to each data impulse storing circuit successively immediately after each of said data impulse storing circuits has been sampled by said sample rotor, switching means for intermittently making connection between said source of erase potential and the erase rotor each time an impulse is taken from said contacts by said sample rotor, and a counter to receive data from said sample rotor.

4. In a counting apparatus, the combination of a plurality of independent data impulse storing circuits, a source of erase potential, a rotary sample switch including a plurality of contacts in circuit with the respective data impulse storing circuits, a sample rotor engageable individually and successively with said contacts and an erase rotor which applies erase potential to each data impulse storing circuit successively immediately after each of said data impulse storing circuits has been sampled by said sample rotor, switching means for intermittently making connection between said source of erase potential and the erase rotor each time an impulse is taken from said contacts by said sample rotor, an impulse receiving tube connected to said sample rotor, a counter, and a counting relay in circuit with said counter and said tube whereby impulses delivered at random to each of said contacts are coordinated to sequentially actuate said counter through said tube.

5. The apparatus as defined in claim 4 wherein said switching means includes an erase relay comprising a coil in circuit with said impulse receiving tube and switch contacts in circuit with said erase potential source and said erase rotor.

6. The apparatus as defined in claim 4 wherein said switching means includes a switching electron tube.

7. The apparatus as defined in claim 5 including a damping capacitor connected in parallel with said erase relay coil.

8. In a counting apparatus, the combination of a plurality of independent data impulse storing circuits, a source of erase potential, a rotary sample switch including a plurality of contacts in circuit with the respective data impulse storing circuits, a sample rotor engageable individually and successively with said contacts and an erase rotor which applies erase potential to each data impulse storing circuit successively immediately after each of said data impulse storing circuits has been sampled by said sample rotor, an impulse receiving tube connected to said sample rotor, a counter, a counting relay in circuit with said counter and said tube whereby impulses delivered at random to each of said contacts are coordinated to sequentially actuate said counter through said tube, and a switching electron tube in circuit with said erase potential source and said erase rotor and operable to intermittently make connection between said erase potential source and said erase rotor each time an impulse is taken from said contacts by said sample rotor, said switching tube including at least one control grid connected by circuit means to said sample rotor and said impulse receiving tube, a cathode adjustably connected to said erase potential source, and a plate in circuit with said erase rotor.

9. The combination of a plurality of separate counting apparatus connected to an impulse switch, each of said counting apparatus including a data storing network adapted to store impulses from said impulse switch, a rotary sample switch having a contact in circuit with said impulse switch and said data storing network, and a counter in circuit with said sample switch to receive impulses therefrom, said data storage network comprising a capacitor connected on a first side in circuit with said impulses switch and ground, and on a second side in circuit with a source of current and ground, said circuit on said second side including also a uni-directional valve which will permit said capacitor to charge when said impulse switch is closed, but will prevent current flow in a loop from one memory capacitor contained in one counter to one memory capacitor contained in the other.

10. In counting apparatus for registering the total machine-hours of production of a group of machines, a plurality of machines, operating means for each machine, a plurality of independent switches in circuit with a source of electric power, and each associated with a respective machine for detecting the operation of said machine, means associated with each machine for automatically closing its associated switch and keeping said switch closed when the machine is operating, and means connected to said switches whereby each of said switches is automatically opened when its respective associated machine is idle, a rotary sample switch including a plurality of contacts in circuit with the respective switches, and a rotor engageable individually and successively with said contacts, an impulse receiving tube connected to said rotor, a counter and a relay in circuit with said counter and said tube whereby impulses are transmitted from said rotor to actuate said counter through said tube, and a constant speed drive means for actuating said rotor whereby said rotor samples the operating status of each of said machines at regular intervals.

References Cited in the file of this patent

UNITED STATES PATENTS

401,366	Osborn	Apr. 16, 1889
1,789,811	Francis et al.	Jan. 20, 1931
1,845,534	Waite	Feb. 16, 1932
1,851,090	Fetter	Mar. 29, 1932
2,074,037	Watson	Mar. 16, 1937
2,908,889	Piety	Oct. 13, 1959