April 7, 1964 G. A. PHLIEGER 3,128,373

COUNTDOWN CLOCK

Filed June 13, 1961 3 Sheets-Sheet 1

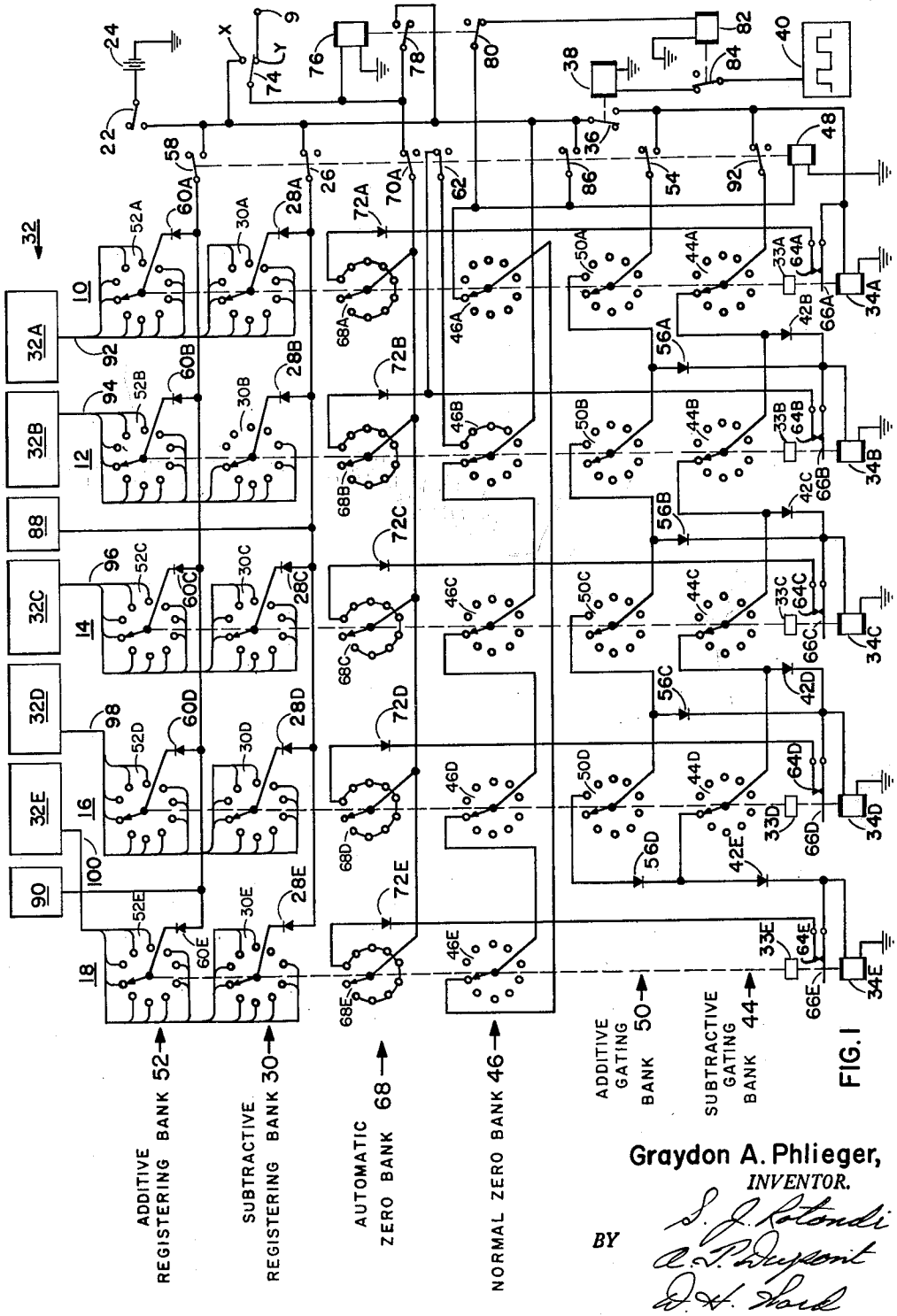


FIG. 1

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COUNTDOWN CLOCK

Filed June 13, 1961 3 Sheets-Sheet 2

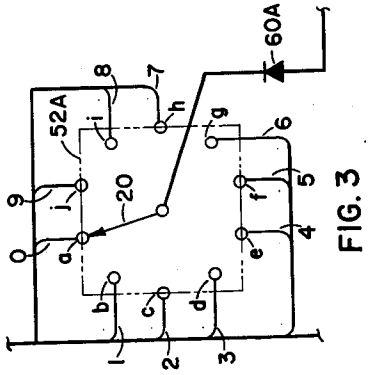


FIG. 3

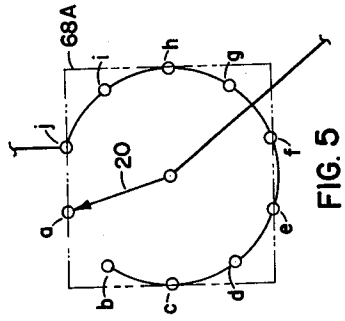


FIG. 5

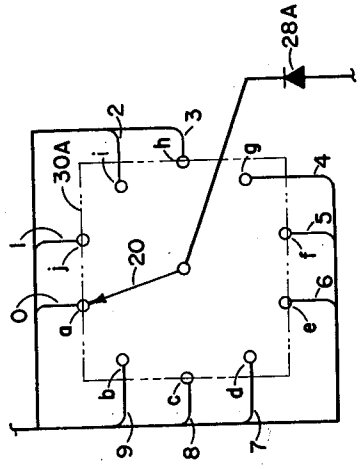


FIG. 4

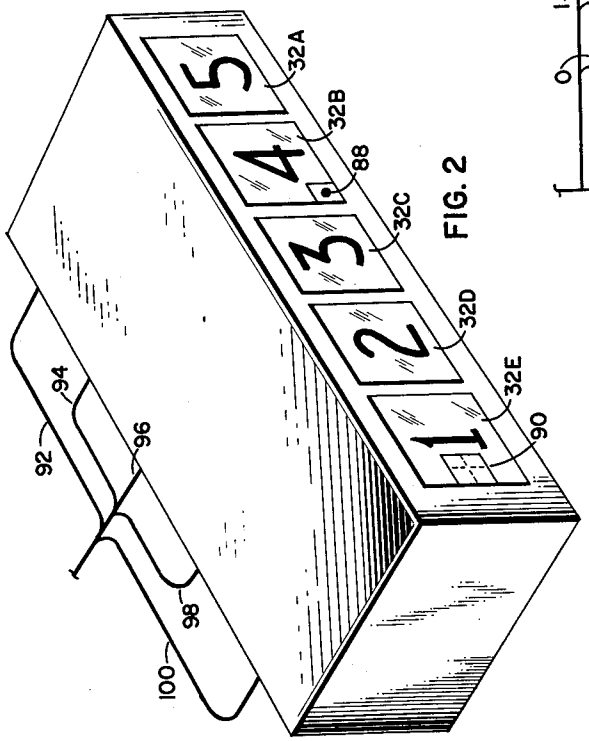


FIG. 2

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COUNTDOWN CLOCK

Filed June 13, 1961 3 Sheets-Sheet 3

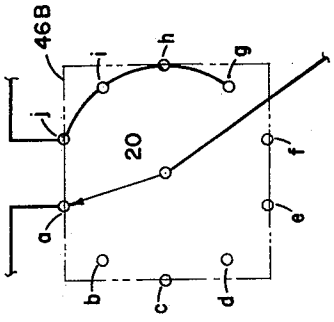


FIG. 8

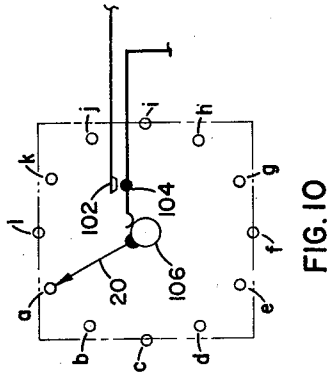


FIG. 10

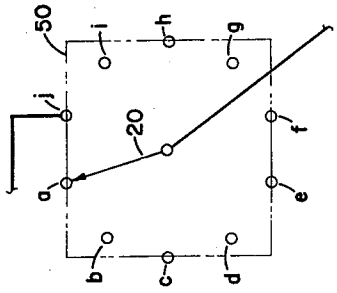


FIG. 7

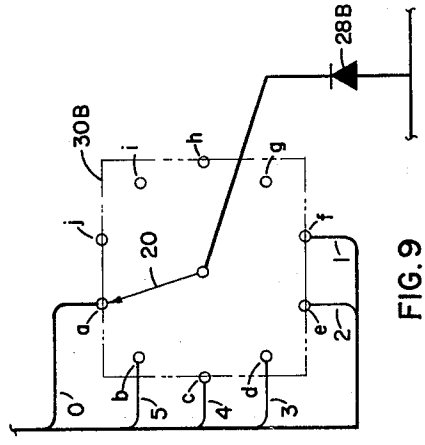


FIG. 9

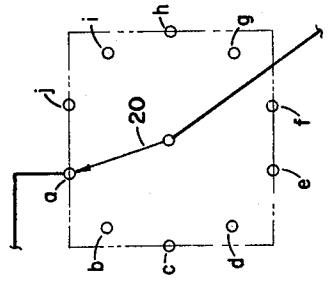


FIG. 6

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United States Patent Office 3,128,373 Patented Apr. 7, 1964

3,128,373

COUNTDOWN CLOCK

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Filed June 13, 1961, Ser. No. 116,888
11 Claims. (Cl. 235—92)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

This invention relates in general to counting devices and in particular to a countdown clock.

This invention employs a digital counting circuit in conjunction with a digital readout to display a series of numbers representative of time whereby an operator may quickly ascertain the elapsed time or time remaining for a particular countdown or timing operation.

In missile launchings, blastings, bomb testings and other activities having a series of complex operations directed toward a final, unrepeatable result, timing is vitally important. The problem of timing has become more complex as the operations have become more numerous and, because of their nature, have been located at remote areas from one another. In order to eliminate inaccuracies, the countdown procedure has come into wide use. During the countdown procedure, an operator reads the time directly from two clocks and his reading is transmitted to all areas simultaneously. The present invention eliminates the possibility of a time differential existing between the clocks in each area. It has been customary to use two clocks for the countdown; one with the conventional face having numbers reading clockwise; the other with an inverted face having numbers readings counterclockwise. Various disadvantages are inherent in the two clock system. For example, it is difficult to read the reverse clock since the inverted face conflicts strongly with the daily experience of viewing and reading conventional clocks. Furthermore, the shifting of attention very rapidly from one clock to the other at zero time presents difficulties and introduces human inaccuracies. This is especially true when the reverse clock reaches zero before the intended zero time, as when a missile fires a few seconds off-schedule. To overcome these difficulties, the present invention provides a single timing means which will give a definite indication of whether it is registering additively or subtractively and which will compensate for inaccuracies at zero time. Therefore, it is a purpose of this invention to provide such a timing means.

The present invention provides a circuit arrangement for the actuation of stepping switches which result in a readout corresponding to time. The circuit arrangement consists of a plurality of switches, each switch having ten contact positions. The switches are arranged in rows and columns. There are six rows or banks of switches—namely, an additive registering bank, a subtractive registering bank, an automatic zero bank, a normal zero bank, an additive gating bank and a subtractive gating bank. The additive and substractive gating banks have four switches per bank while the remaining banks each have five switches. There are five columns of switches with each column having a central shaft to provide a series of ganged switches. At the top of this circuit arrangement and electrically connected thereto, is a readout assembly.

A first ganged switch is actuated by a voltage source once every second while a second ganged switch adjacent to the first is actuated once for every ten actuations of this first switch. This is accomplished by gating the voltage source through one contact of an individual switch on the first ganged switch to the actuating means of the

adjacent or second ganged switch. Separate banks of switches are provided for gating and supplying voltage to the readout, one each for additive counting and one each for subtractive counting. Another bank of switches is provided which completes a path from the voltage source to a lock-in switching means when all switches of this bank are at a zero position. When activated the lock-in switching means removes voltage from the subtractive bank and applies it to the additive bank. The additive bank for supplying voltage to the readout has all but the zero contacts connected to the display means in inverse order to those of the subtractive bank. The readout may be a digital type having edge-lighted plastic sheets with engraved numbers. Voltage applied to a particular light will illuminate a respective number.

A means for differentiating between additive counting and subtractive counting may be provided by several circuit forms. The preferred form provides for the display of a plus sign for an additive count and a decimal point between the seconds and minutes for a subtractive count. The circuit form may be changed to provide any combination of seconds, minutes and hours. The preferred embodiment displays seconds and minutes for a subtractive count and only seconds for an additive count. By the use of other combinations of form, this circuit can also be used for counting and registering numbers which need not be proportional to time.

The control signals, which are pulses of voltage, will be regarded for the purpose of the above description as due to the making and breaking of the circuit to the voltage source. The making of the circuit corresponds to the start of the voltage pulse and the breaking of its circuit to its end. It will, however, be understood that other means of obtaining appropriate voltage differential can be used. The switches will be regarded as being actuated at the end of the voltage pulse. This is accomplished by the use of a ratchet imposed between each switch and the actuating means of that switch.

In practice it may be found that ganged switches with the desired number of contacts per individual switch are not available. In such cases, a cam can be used with associated contacts operative from the subtractive gating bank to step the switch past the unused contacts. The cam is used to hold the contacts together over the range of the unused contacts and thereby supply voltage to the actuating means of that switch.

The invention may be better understood through the following specification, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a schematic of the invention for a countdown clock application.

FIGURE 2 is the digital readout of FIGURE 1 with a number displayed thereon.

FIGURE 3 shows a switch from the additive registering bank of FIGURE 1.

FIGURE 4 shows a switch from the subtractive registering bank of FIGURE 1.

FIGURE 5 shows a switch from the automatic zero bank of FIGURE 1.

FIGURE 6 shows a switch from the normal zero bank and the subtractive gating bank of FIGURE 1.

FIGURE 7 shows a switch from the additive gating bank of FIGURE 1.

FIGURE 8 shows a switch from the normal zero bank for zeroing at the count of six.

FIGURE 9 shows a switch from the subtractive registering bank for registering only six digits.

FIGURE 10 shows a switch from the subtractive gating bank with an arrangement of a cam and associated contacts for zeroing the switches if the number of contacts per bank are more than the radix of the numbering system used.

In the following description, like numerals designate similar components.

In FIGURE 1, a series of ganged switches **10**, **12**, **14**, **16**, **18** is shown. Ganged switches **10**, **12**, **14**, **16** comprise six individual switches or sections having a plurality of stationary contacts and a movable contact. As more clearly shown in FIGURE 3, movable contact **20** of each switch has positions corresponding with contacts *a* to *j*. As shown in the different columns of switches, the dotted lines designate a structural connection between components causing them to operate in a "ganged" manner. The digital readout **32** is shown at the top of FIGURE 1 as well as FIGURE 2. This readout consists of a series of window display numbers which use a stack of plastic sheets having engraved numbers superimposed on one another to provide the desired numerical display. Each of the sheets can be edge-lighted to bring its particular number into prominence. The edge-lighting is controlled by a series of stepping relays which will be more fully described hereafter. Located below the digital readout is the additive registering bank **52**, the subtractive registering bank **30**, the automatic zero bank **68**, the normal zero bank **46**, the additive gating bank **50** and the subtractive gating bank **44**.

The circuit in FIGURE 1 is placed in operation by closing on-off switch **22** whereby voltage source **24** is connected through switch **26** to diodes **28A**, **28B**, **28C**, **28D**, **28E** and movable contacts **20** of the subtractive registering bank **30**. A voltage impressed on contacts *a* to *j* (see FIGURE 4) of ganged switches **10**, **14**, **16**, **18** of the subtractive registering bank from the respective movable contacts **20** cause each associated window of readout **32** to register the numbers 0, 9, 8, 7, 6, 5, 4, 3, 2, 1, respectively. Therefore, as movable contacts **20** of subtractive registering bank **30** of switches **10**, **14**, **16**, **18** are moved from contact *a* to *b* to *c*, etc., readout **32** registers 0, 9, 8, etc., respectively. As movable contacts **20** of subtractive registering bank **30** of switch **12** is moved from contact *a* to *b* to *c*, etc., readout **32D** registers 0, 5, 4, etc., respectively. The display therefore depends upon the position of movable contacts **20**.

To operate movable contacts **20** of gang switch **10**, a control signal **40** actuates coil **38** which in turn closes switch **36**. Coil **38** and switch **36** can be considered as a pulsing means for supplying voltage to coils **34**. When switch **36** is closed, voltage source **24** actuates coil **34A** which tensions a spring loaded ratchet **33A**. At the end of a pulse from control signal **40** switch **36** opens, removing voltage from coil **34A**. When voltage is removed from coil **34A**, it releases ratchet **33A** which turns movable contacts **20** to a next position or contact. To operate the movable contacts **20** of gang switches **12**, **14**, **16**, it is necessary to analyze the circuitry associated with the subtractive gating bank **44**. Coils **34B**, **34C**, **34D**, **34E** are connected through diodes **42B**, **42C**, **42D**, **42E** to contacts *a* of switches **44A**, **44B**, **44C**, **44D**. In order to actuate coil **34B**, the movable contact **20** of switch **44A** must be in the *a* position. To actuate coil **34C**, the movable contacts **20** of switch **44A** and **44B** must be in position *a*. Accordingly, it follows that coil **34E** can only be actuated when the movable contacts **20** are at position *a* in switches **44A**, **44B**, **44C**, **44D**. In this manner, a pulse from control signal **40** closes switch **36** and allows a voltage from source **24** to rotate movable contact **20** of switch **44A** one step. The number of steps the contact **20** makes will depend on the initial location of this movable contact. Each pulse will rotate the contact **20** one step. After contact **20** of switch **44A** is stepped to position *a*, a circuit will be completed through diode **42B** to actuate coil **34B**. This in turn will, through ratchet **33B**, turn contact **20** of switch **44B** one step. It thus becomes apparent that contact **20** of switch **44B** moves only one step for every ten steps of contact **20** in switch **44A**. Likewise, movable contact **20** of switch **44C** moves only one step for every ten steps of contact **20** in switch **44B**.

Eventually, all the movable contacts **20** in the subtractive gating will be in position *a* so that readout **32** will display all zeros.

To change over from subtractive counting to additive counting, a normal zero bank **46** is provided. Voltage source **24** is connected through switch **22** to movable contact **20** of switch **46B**. Contact *a* of switches **46B**, **46C**, **46D**, **46E** is connected to movable contacts **20** of switches **46C**, **46D**, **46E**, **46A**, respectively. Contact *a* of switch **46A** is connected to coil **48**.

Contacts *g*, *h*, *i*, *j* of switch **46B** are connected together and through switch **62** to contact **64B** of gang switch **12**. Contacts **64B** and **66B** are closed until coil **34B** is actuated, so that voltage source **24** is connected through movable contact **20** of switch **46B** to coil **34B** for actuation thereof. When movable contact **20** and contact *g* of switch **46B** come in contact, coil **34B** tensions ratchet **33B** and opens contact **64B** and **66B**. As ratchet **33B** is released, it moves movable contact **20** to contact *h* of switch **46B**. The operation repeats for contacts *h*, *i*, *j*, as movable contact **20** connects with contacts *h*, *i*, *j* of switch **46B**. This series connection restricts readout **32B** to register only six digits thereby allowing a count of seconds in readouts **32A** and **32B** for the subtractive counting operation. Readouts **32C**, **32D**, **32E** are used to indicate minutes. Normal zero bank **46** being connected in the above described manner actuates coil **48** when movable contacts **20** of switches **46A**, **46B**, **46C**, **46D**, **46E** are in position *a*, the zero position. Actuation of coil **48** opens the circuit from voltage source **24** through switch **92** to subtractive gating bank **44** and through switch **26** to subtractive registering bank **30** and closes the circuit from voltage source **24** through switch **54** to additive gating bank **50**, through switch **58** to additive registering bank **52**, and through switch **86** to coil **48**.

Additive gating bank **50** operates and actuates coil **34B** in a similar manner to that of subtractive gating bank **44**. Switch **54** is connected to movable contact **20** of switch **50A**. Contact *j* of switches **50A**, **50B**, **50C** is connected to movable contacts **20** of switches **50B**, **50C**, **50D**, respectively. Contact *j* of switches **50A**, **50B**, **50C**, **50D** is connected through diodes **56A**, **56B**, **56C**, **56D** to coils **34B**, **34C**, **34D**, **34E**, respectively.

Additive registering bank **52** controls the display of readout **32** in a similar manner to subtractive registering bank **30**. Voltage source **24** supplies voltage to readout **32** through switches **22** and **58**, diodes **60A**, **60B**, **60C**, **60D**, **60E** and contacts *a* to *j* of additive registering bank **52**. As movable contact **20** is moved from contact *a* to *b* to *c*, etc., readout **32** registers the numbers 0, 1, 2, etc., respectively.

A requirement for zeroing all switches is satisfied by employing automatic zero bank **68**. Movable contacts **20** of automatic zero bank **68** are connected through switch **70** to coil **76** and normally opened switch **78** to voltage source **24**, and through switches **70** and **74** to terminal **9**. Switch **74** is spring-loaded and has contacts and correspond positions *x* and *y*. Position *y* is the normal, nondepressed position of switch **74**. Contact *x* is connected to voltage source **24** and contact *y* is connected to terminal **9**. Terminal **9** is disposed for connection to equipment which supplies a control signal at the occurence of the timed event or as selectively desired. The event, for purposes of this description, is the lift-off of a missile. Contacts *b* to *j* of automatic zero bank **68** are connected together and through diodes **72A**, **72B**, **72C**, **72D**, **72E** to contacts **64A**, **64B**, **64C**, **64D**, **64E**. This circuit arrangement of automatic zero bank **68** will actuate coils **34A**, **34B**, **34C**, **34D**, **34E** when movable contacts **20** are in positions *b* to *j*. Coils **34A**, **34B**, **34C**, **34D**, **34E** actuate ratchets **33A**, **33B**, **33C**, **33D**, **33E** which rotate movable contatcs **20** until they come in contact with contact *a* of automatic zero bank **68**, breaking the circuit between coils **34A**, **34B**, **34C**, **34D**, **34E** and terminal **9**. Switch **70** is utilized so that zeroing of the switches can be accom-

plished only during a subtractive count. Voltage is supplied to movable contacts **20** of automatic zeroing bank **68** when a control signal at terminal **9** actuates coil **76** to close switch **78** and connect it to voltage source **24**. If the switches need to be zeroed by other than external equipment connected at terminal **9**, switch **74** can be depressed to position *x*, connecting movable contacts **20** of automatic zero bank **68** directly with voltage source **24**.

Because missile lift-off or any timed event might not occur exactly at zero time, a circuit containing switch **80**, coil **82**, and switch **84** has been included. Contact *a* of switch **46A** is connected through switch **80** to coil **82**. Switch **84** is connected between control signal **40** and coil **38**. When movable contacts **20** of normal zero banks **46** are in position *a*, a voltage from source **24** is impressed on coil **82** opening switch **84** and removing control signal **40** from the circuit.

At the occurrence of the timed event a control signal is supplied to terminal **9** actuating coil **76**. Actuation of coil **76** opens switch **80** breaking the connection to coil **82** and allowing switch **84** to close which connects control signal **40** to coil **38**. If the event occurs before movable contacts **20** are in position *a*, the zero time, a control signal at terminal **9** will zero the switches and the next pulse from control signal **40** will begin the additive count. If the event occurs exactly at zero time, there will be no interruption in changing from subtractive counting to additive counting. If the event occurs after zero time, control signal **40** will be removed from coil **38** until the occurrence of the event; at which time the control signal at terminal **9** will cause the opening of switch **80** and the connection of control signal **40** to coil **38**.

To enable the operator to distinguish between subtractive counting and additive counting, two additional readouts **88** and **90** are utilized. Readout **88**, which is mounted between readouts **32B** and **32C**, is connected through switch **26** to voltage source **24** and displays a decimal point. Voltage is supplied to readout **88** only during the subtractive count and makes a division between the displayed seconds and minutes. Readout **90** is connected through switch **58** to voltage source **24** and displays a plus sign before readout **32**. Voltage is supplied to readout **90** only during the additive count of seconds. Switches **30A**, **30B**, **30C**, **30D**, **30E** and **52A**, **52B**, **52C**, **52D**, **52E** are connected by cable harnesses **92**, **94**, **96**, **98**, **100**, respectively, to readouts **32A**, **32B**, **32C**, **32D**, **32E**.

FIGURE 2 illustrates the preferred embodiment of the readout **32** of gang switches **10**, **12**, **14**, **16**, **18**. Readout **32** illustrates a display of a typical number. The displayed number 123.45 corresponds to 123 minutes and 45 seconds. The plus sign is shown in dotted lines in readout **32E**. During the additive count therefore, the display would appear as +123.45 without the decimal point indicating 12,345 seconds have elapsed since the occurrence of the timed event. To have a display of +12345 on readout **32**, movable contacts **20** of gang switches **10**, **12**, **14**, **16**, **18** must be in positions *b*, *c*, *d*, *e*, *f*, respectively. To have a display of 123.45, movable contacts **20** of gang switches **10**, **12**, **14**, **16**, **18** must be in positions *j*, *i*, *h*, *g*, *f*, respectively.

FIGURE 3 illustrates contacts *a* to *j*, movable contact **20**, and diode **60A** of switch **52A**. Connections from contacts *a* to *j* are shown with the numbers 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, illustrating connections to corresponding number readouts on readout **32A**. The other switches in bank **52** would have this same configuration.

FIGURE 4 illustrates contacts *a* to *j*, movable contact **20**, and diode **28A** of switch **30A**. Connections from contacts *a* to *j* are shown with the numbers 0, 9, 8, 7, 6, 5, 4, 3, 2, 1, illustrating connections to corresponding number readouts of readout **32A**. The other switches in bank **30** would have this same configuration.

FIGURE 5 illustrates contacts *a* to *j* and movable contact **20** of switch **68A**. As described above, contacts *b* to *j* are connected together. The other switches in bank **68** have the same configuration.

FIGURE 6 illustrates contacts *a* to *j* and movable contact **20** of switch **46A** and switch **44A**. The other switches in banks **44** and **46** would have the same configuration except for switch **46B**.

FIGURE 8 illustrates contacts *a* to *j* and movable contact **20** of switch **46B**. As shown and described above, contacts *g*, *h*, *i*, *j* are connected together so that readout **32B** will register only the numbers 0, 1, 2, 3, 4, 5 during the subtractive count restricting it to counting tens of seconds.

FIGURE 9 illustrates contacts *a* to *j*, movable contact **20** and diode **28A** of switch **30A**. Connections from contacts *a* to *f* are shown with the 0, 5, 4, 3, 2, 1 illustrating connections to corresponding number readouts of readout **32B**.

FIGURE 10 illustrates a switch which could be substituted for **44B** with an arrangement of cam **106** and contacts **102** and **104** for zeroing a switch if the number of contacts per switch are more than that desired. Contacts *a* to *l* are shown as an example. If contacts *a* to *j* are to be used, cam **106** will close contacts **102** and **104** when movable contact **20** is in position to connect with contacts *k* and *l*. Contact **102** is connected to voltage source **24** and contact **104** is connected to contact **64B** of FIGURE 1. Closing contacts **102** and **104** will actuate coil **34B** and move movable contact **20** past contacts *k* and *l* to contact *a*.

As many changes could be made in the above construction and many different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A counting device for singly and successively registering digits subtractively and additively corresponding to the incidence of a control signal comprising a plurality of successively disposed gang switches, each of said gang switches including; a plurality of individual sections respectively having a radix of stationary contacts and a movable contact successively cooperative with said stationary contacts, an actuating means cooperative with said movable contact of each section for stepping said switch, a display means having as many display units as said radix with each of said display units connected to a corresponding stationary contact of a first of said sections for displaying a separate and distinct digit, a first diode connected between a first stationary contact of a second of said sections and said actuating means of a next succeeding one of said switches, the first stationary contact of said second section connected to a movable contact of a second section of a next succeeding one of said switches; a pulsing means responsive to said control signal; a voltage source; a first normally closed contact set connected between said voltage source and the movable contact of said first section of each of said switches; and a second normally closed contact set connected between said pulsing means and the movable contact of said second section.

2. A counting device as in claim 1 with a second diode connected between a last stationary contact of a third of said section of each of said switches and said actuating means of a next succeeding one of said switches, said last stationary contact of said third section connected to the movable contact of said third section of a next succeeding one of said switches, each of said display units connected to a corresponding stationary contact of a fourth of said sections of each of said switches; a first normally opened contact set connected between said voltage source and the movable contact of said fourth section of each of said switches for supplying voltage to said display means; a second opened contact set connected between said pulsing means and the movable contact of said third section of a

first of said switches; a first coil coperative with said first and said second normally opened contact sets and with said first and said second normally closed contact set for actuation thereof; a switching means connected between said voltage source and said first coil for actuation thereof.

3. A counting device as in claim 2 wherein said switching means includes a third normally opened contact set, said first coil cooperative with said third normally opened contact set for actuation thereof, said voltage source connected to said movable contact of a fifth of said sections of a second of said switches, a first stationary contact of said fifth section of said first switch connected between said switching means and said first coil, a first contact of said fifth section of a next succeeding one of said switches.

4. A counting device as in claim 3 comprising an automatic zero source, a third normally closed contact set connected between said automatic zero source and the movable contact of a sixth of said sections of each of said switches, a second contact connected to succeeding of the remaining stationary contacts of said sixth section, an interrupter contact set including two points, a diode connected between said second contact of said sixth section and one of said points, other of said points connected to said actuating means, said actuating means cooperative with said interrupter contact set for actuation thereof, whereby said automatic zero source will step all switches until the movable contacts come in contact with said first stationary contact of each of said sections of all said switches.

5. A counting device as in claim 4 wherein said pulsing means includes a fourth normally opened contact set, a second coil cooperative with said fourth normally opened contact set for actuation thereof, said fourth normally opened contact set connected between said voltage source and said actuating means of said first switch; a fourth normally closed contact set; said control signal connected through said fourth normally closed contact set to said second coil for intermittent actuation of said fourth opened contact set.

6. A counting device as in claim 5 wherein said control signal has a constant rate of one pulse per second.

7. A counting device as in claim 6 where in each of

said switches, a first stationary contact of said first and said fourth sections are connected to a first display unit, remaining of said stationary contacts of said first section connected to corresponding of said display units in successive order, remaining of said stationary contacts of said fourth section connected in inverse successive order to corresponding of said display units whereby said first section will connect said voltage source to said display means for registering digits successively and additively and said fourth section will connect said voltage source to said display means for registering digits successively and subtractively.

8. A counting device as in claim 7 wherein said radix is equal to ten so that said display means will register time in a numbering system of base ten.

9. A counting device as in claim 8 where in said second switch, a seventh stationary contact is connected to an eighth, ninth and tenth stationary contact of said fifth section, a fifth normally closed contact set connected between said seventh contact of said fifth section and said one of said points whereby said actuating means will step the movable contacts of said second switch so that said display means will register six digits in an additive count.

10. A counting device as in claim 9 in which said first coil cooperates with said third and fifth normally closed contact sets.

11. A counting device as in claim 10 wherein said switching means includes a fifth normally opened contact set, a third coil cooperative with said fifth normally opened contact set for actuation thereof, a sixth normally opened contact set having a normally opened contact connected to said voltage source, a normally closed contact connected to said automatic zero source, a wiper arm cooperative with said normally closed contact and said normally opened contact and connected to said third coil, said wiper arm connected through said third and fifth normally opened contact sets to said second coil.

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