Dec. 21, 1965 V. J. LEONARD 3,224,673

PREDETERMINING COUNTER

Filed Oct. 30, 1963 3 Sheets-Sheet 1

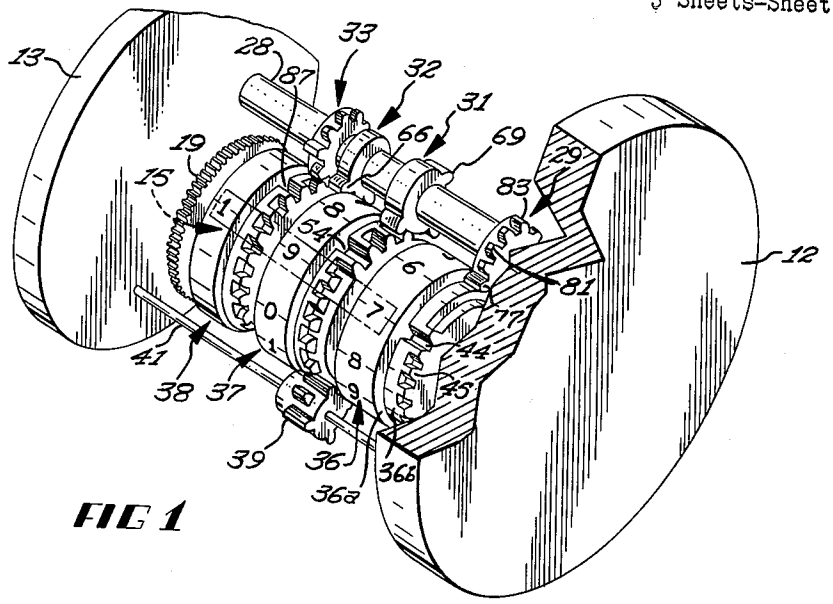


FIG 1

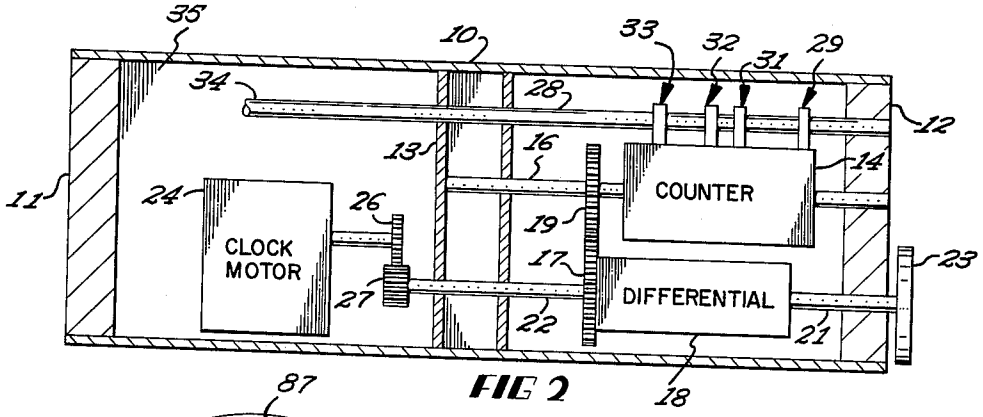


FIG 2

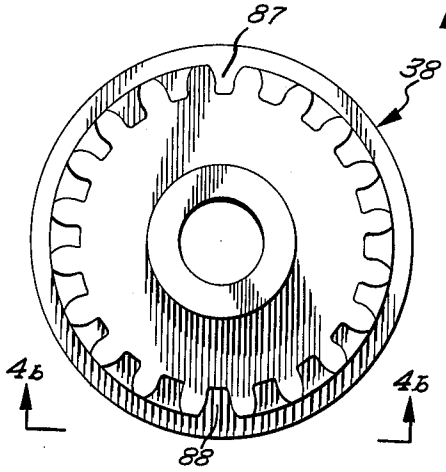


FIG 4a

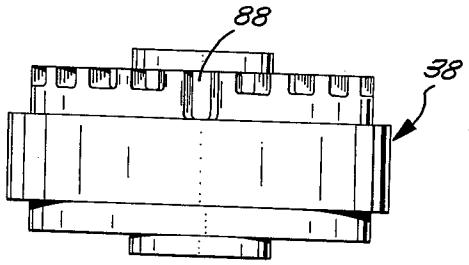


FIG 4b

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PREDETERMINING COUNTER

Filed Oct. 30, 1963 3 Sheets-Sheet 2

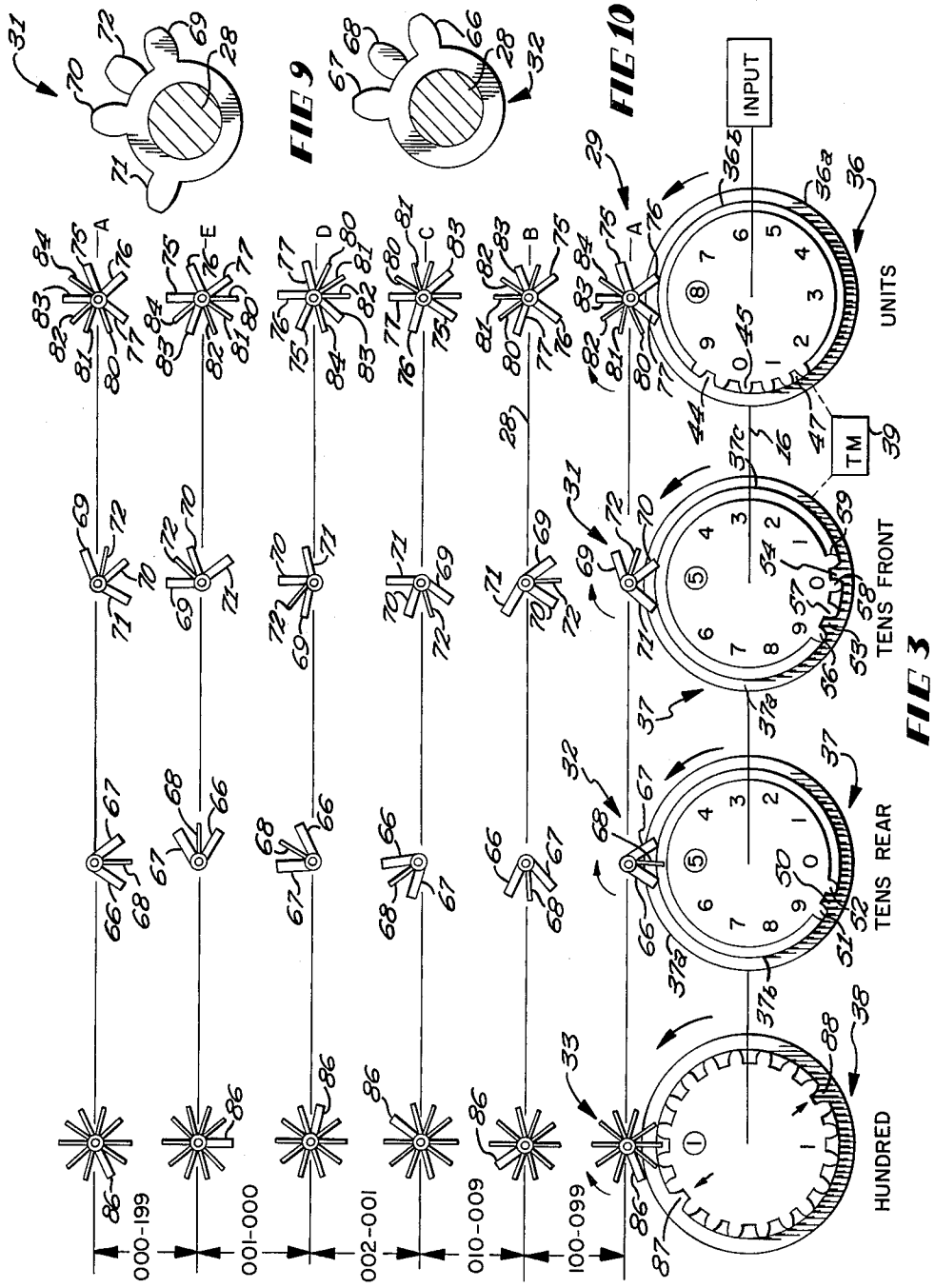


FIG 9

FIG 10

FIG 3

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PREDETERMINING COUNTER

Filed Oct. 30, 1963 3 Sheets-Sheet 3

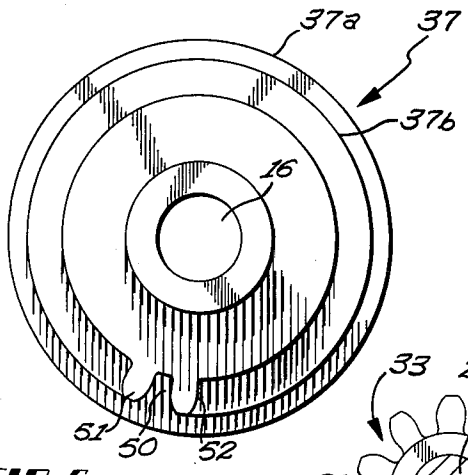


FIG 5a

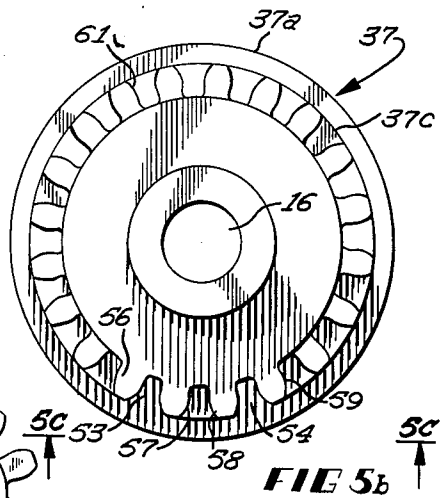


FIG 5b

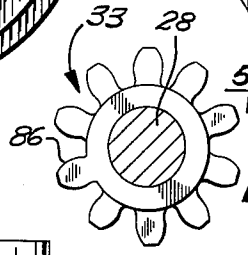


FIG 11

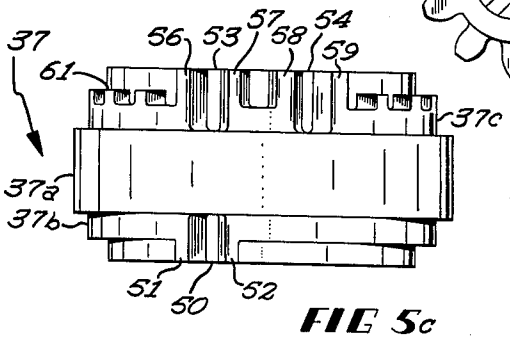


FIG 5c

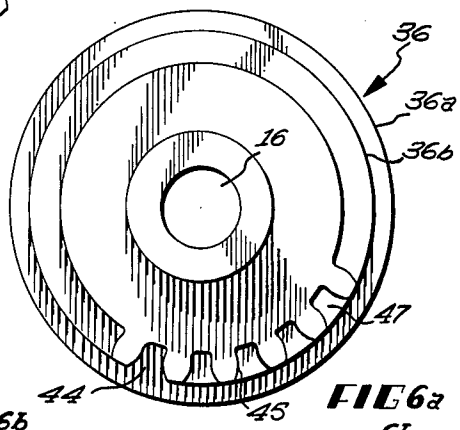


FIG 6a

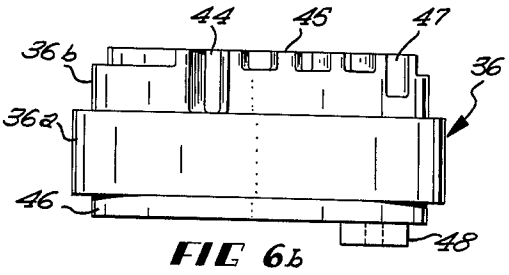


FIG 6b

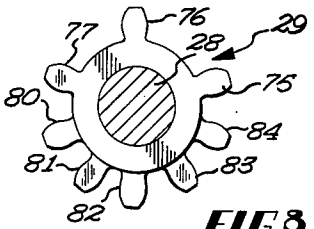


FIG 8

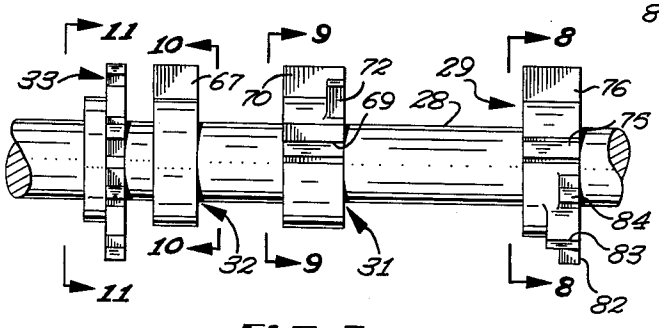


FIG 7

United States Patent Office 3,224,673 Patented Dec. 21, 1965

3,224,673

PREDETERMINING COUNTER

Vurnen J. Leonard, Minneapolis, Minn., assignor to Honeywell Inc., a corporation of Delaware

Filed Oct. 30, 1963, Ser. No. 320,133
10 Claims. (Cl. 235—132)

This invention relates generally to an improved output device for a predetermining counter and more specifically concerns the design of an automatically resettable mechanical output shaft which will provide a rotational output at the end of a predetermined count, the prior structure of which is described in co-pending application Serial No. 302,310, filed August 15, 1963, also assigned to the applicant's assignee.

The predetermining counter which was described in the co-pending application provided a rotary output from a mechanical output shaft at the end of a predetermined count. Since the counter was used in a timing device for a mechanical munition fuze, the output was utilized for arming the fuze at the end of a preset time period. This particular timing device including a predetermining counter having a rotary output shaft is particularly well adapted for use in a munition fuze. First of all, the counter is easily set to the desired time even by the most inexperienced operator. The counter mechanism is simply rotated until the correct time appears on the dials. The counter is also inherently very accurate since the final output is taken directly from the lowest order counter wheel, each revolution of which represents a relatively short time period. In this particular application, one revolution of the lowest order wheel represents ten seconds of time. If accuracy to one second is desired, thirty-six degrees of rotation is available for transfer to the output shaft.

The fact that the output shaft is geared to the counter wheels at all times during the countdown is also highly desirable in that the output shaft is not affected by vibration or inertial forces. A spring loaded device, for example, might be influenced by such vibration to give an erroneous output.

The prior structure as disclosed in the co-pending application had a drawback in that the output shaft would not automatically reset with the counter. If, for example, an operator set in the wrong time on the counter thus requiring a subsequent change in setting, the output shaft in some circumstances had to be removed from engagement with the counter wheels until the counter was reset. The prior device would reset in a countdown direction without separately changing the position of the output shaft, but any changes in setting in a forward direction involving motion of the output shaft required that the output shaft be disengaged. Separate resetting of the shaft was also required if the counter were reset through the zero position in either direction.

As can readily be seen, it is highly desirable that the output shaft follow the movement of the counter wheels at all times. If the output shaft is engaged at all times and will follow the movement of the counter wheels, the operator need only adjust the position of the counter wheels and need not be concerned with the setting of the output shaft. This automatic resetting feature reduces the probability of errors being introduced into the setting of the counter and also reduces the time required to reset the counter. A remote setting system can also be utilized where the output shaft will follow the counter but cannot be conveniently utilized if the output shaft must be separately rest each time the counter is reset.

In the prior structure, shaft rotating means comprising a plurality of kicker teeth and blocking teeth were placed on the output shaft in position to be engaged by corresponding driving means or cog members on the

counter wheels as each counter wheel returned to the zero position for the last time. That is, as the highest order wheel returned to zero, a cog member on the wheel contacted a kicker tooth on the output shaft to partially rotate the output shaft. This partial rotation placed a second kicker tooth in position to be contacted by a cog member on the next lower wheel as it returned to the zero position. This sequence of events continued until a final kicker tooth was placed in position adjacent the lowest order wheel to be contacted by a cog member when the lowest order wheel reached the zero position for the last time. The final partial output which occurred when the lowest order wheel reached the zero position for the last time was utilized to arm the fuze. Again it should be noted that the prior structure was not reversible. It was not possible to drive the wheels in a forward direction to reset the output shaft unless the output shaft were disengaged and manually reset.

The present invention utilizes similar theory to accomplish the rotation of the output shaft in a countdown direction but also provides means to automatically reset the output shaft when the counter is reset. In the improved device, additional kicker teeth, blocking teeth cog members and notches for the blocking teeth are added wherever necessary to insure that a kicker tooth is in position to be engaged by an associated cog member regardless of the position of the counter wheels and regardless of the direction in which the wheels are turned.

The theory of operation in the particular case of a three wheel counter can be explained as follows. A standard counter mechanism is constructed such that it will rotate in either direction from the zero position to the maximum number position having three digits. The total range of the counter thus includes the zero position and all numbers through the maximum number having three digits. The total range can be divided into three sub-ranges, the lower limit of each being defined by the counter position as each wheel returns to the zero position for the last time in a countdown direction and the high limit being defined by the counter positions at which each counter wheel transfers movement to the next higher counter wheel for the first time in a forward direction. In a three-wheel counter capable of counting from 000 to 999, for example, the low range has a low limit of 000 and a high limit of 009; the middle range has a low limit of 010 and a high limit of 099; and the high range has a low limit of 100 and a high limit of 999. During the time that the counter is in the high range, a kicker tooth on the output shaft is placed in position to be contacted by a cog member on the highest order wheel should the counter pass through either the high or low limit of the high range. The kicker teeth corresponding to the two lower order wheels or two lower ranges must of course be mounted on the output shaft so as to be out of line with the two lower order wheels during this period since each of the lower order wheels will make several revolutions during this period. If the counter leaves the third range in a countdown direction, the kicker tooth will be engaged to rotate the output shaft a partial turn to place the next lower kicker tooth in position to be contacted by the associated cog member should the counter move through the limits of the middle range. If the counter moves through the high limit of the high range, it will move into the low range and again the kicker tooth corresponding to the low range is placed in position to be contacted by the associated cog member.

The counter will of course repeatedly count from 000 to 999 in a forward direction or repeatedly count from 999 to 000 in a countdown direction. In order that the several positions of the output shaft correspond to the several positions of the counter, a full revolution of the

output shaft is made to represent the rotation of the counter through its full range. Because of this, the counter can be indiscriminately rotated in any direction for any length of time without losing the fixed relative relationship existing between the positions of the output shaft and the ranges of the counter wheels.

The basic thing to remember is that an output is desired at some point during the final rotation of the lowest order wheel. Since the lowest order wheel is continuously rotating, it is impossible to place a mechanical device in position to be contacted by the lowest order wheel until it reaches the final rotation. The movement of the higher order wheels is thus utilized to predict the arrival of the lowest order wheel at the final rotation and to control the output means accordingly. When the lowest order wheel completes its final rotation in either direction, the output is utilized to reset the output shaft to a previous position corresponding to the range into which the counter is moved.

The particular embodiment of the counter disclosed in this application provides repeatable counting in either direction between 000 and 199. The theory of operation is the same as that discussed above, however, and will be discussed in detail in a later portion of the specification.

An unusual setting mechanism and driving mechanism has also been incorporated into the timer. A mechanical differential having two separate inputs and a common output is utilized. The differential output is geared to the lowest order wheel. A setting knob is connected to one input such that the lowest order wheel can be rotated in either direction through the differential. A clock motor is connected to the other input whereby the lowest order wheel is driven at a predetermined rate when the clock is operating. Since one input can be made without affecting the position of the other input, no switch-over arrangement is required between the setting operation and the operation of the time clock.

It is therefore a primary object of the present invention to provide an automatically resettable output mechanism for a predetermining counter.

It is a further object to provide an output device which is geared to the wheels of a multiple wheel counter such that an output will occur during a selected single rotation of the lowest order wheel, the counter being resettable such that each time said counter returns to the output position an output occurs.

Another object of the present invention is to provide a rotary output shaft for a mechanical counter which has mounted thereon a plurality of segmental gears which mesh with corresponding segmental gears on the counter wheels such that the output shaft has a plurality of fixed positions corresponding to a plurality of counter wheel positions.

Yet another object of the present invention is to provide an output device for a predetermining counter which will assume a plurality of positions in response to the counter moving from a predetermined number setting to a reference setting and which will automatically reset upon said counter being returned to the original setting.

Another object of the present invention is to provide a munition fuze timer including a predetermining counter having an automatically resettable output mechanism and having a dual input including manual setting means and timed driving means each being operable at all times without disconnecting the other.

A still further object of the present invention is to provide a timing device utilizing a predetermining counter having an intermittently driven output shaft which rotates at comparatively high speed during movement of the counter through relevant readings to permit a time pick-off as accurate as could be achieved by an output dial or shaft of the size necessary to permit continuous rotation at the same speed over the same period of time.

These and other objects of the present invention will become apparent from the following description, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is an isometric view of the predetermining counter with the output shaft in a position corresponding to the highest range of positions on the counter.

FIGURE 2 is a side view of the subject munition fuze timer disclosing the location of and the relationships between the driving means, the setting means, the counter and the output shaft.

FIGURE 3 is a schematic representation of the counter mechanism and output shaft showing the position of the output shaft at five different stages of the counting cycle.

FIGURE 4*a* is a side view of the hundreds wheel; the side being that side adjacent the tens wheel.

FIGURE 4*b* is a view of the hundreds wheel taken along line 4*b*—4*b* of FIGURE 4*a*.

FIGURE 5*a* is a side view of the tens wheel; the side being that side adjacent the hundreds wheel.

FIGURE 5*b* is a side view of the tens wheel; the side being that side adjacent the units wheel.

FIGURE 5*c* is a view of the tens wheel taken along lines 5*c*—5*c* of FIGURE 5*b*.

FIGURE 6*a* is a side view of the units wheel; the side being that side opposite the side adjacent the tens wheel.

FIGURE 6*b* is a view of the units wheel taken along lines 6*b*—6*b* of FIGURE 6*a*.

FIGURE 7 is a side view of the output shaft disclosing the relative positions of a number of the kicker teeth and blocking teeth attached thereto.

FIGURE 8 is a side view of the kicker teeth and blocking teeth associated with the units wheel taken along line 8—8 of FIGURE 7.

FIGURE 9 is a side view of the kicker teeth and blocking teeth associated with the front of the tens wheel as taken along line 9—9 of FIGURE 7.

FIGURE 10 is a side view of the kicker teeth and blocking teeth associated with the rear of the tens wheel as taken along line 10—10 of FIGURE 7.

FIGURE 11 is a side view of the kicker teeth and blocking teeth associated with the hundreds wheel as taken along line 11—11 of FIGURE 7.

Refer now to the drawings for a more detailed description of the predetermining counter and its operation. In FIGURE 2, the subject munition fuze timer is disclosed in block form. The timer assembly is mounted in a cylindrical frame **10** having end supports **11** and **12**, and a central support **13**. A multiple wheel counter **14** is mounted on a rotatable shaft **16** between supports **12** and **13**. Counter **14** can be driven in either direction by rotation of shaft **16**. An output gear **17** of a mechanical differential **18** is connected to a matching gear **19** attached to shaft **16** to provide rotation of shaft **16**. Two inputs to differential **18** are provided including a shaft **21** and a shaft **22**. A setting knob **23** is connected to input shaft **21** to provide means for manually setting the counter in either direction. A clock motor **24** is connected through intermediate gears **26** and **27** to input shaft **22** to drive counter **14** during operation of the timer. The two inputs to the counter are independent. The rotation of setting knob **23** in either direction will cause gear **17** to rotate, to in turn rotate counter shaft **16**. During the manual setting operation, input shaft **22** remains stationary. Likewise, during operation of clock motor **24**, input shaft **21** remains stationary.

An output shaft **28** is mounted adjacent counter **14** for rotation in support members **12** and **13**. The individual output means or shaft rotating means **29**, **31**, **32**, and **33** are disclosed in block form. Shaft rotating means **29**, **31**, **32**, and **33** are engaged with corresponding driving means on counter **14** in a manner to be described later. An end **34** of output shaft **28** extends into a chamber **35** located between supports **11** and **13**. Although not disclosed in this drawing, end **34** is connected to the fuze arming system so as to arm the fuze at the end of the predetermined count.

Referring now to FIGURE 1, the predetermining counter including the output shaft is disclosed in detail in an isometric view. The counter wheels are again mounted between support members **12** and **13** on a common shaft **16** (not shown). The counter wheels include a units wheel **36**, a tens wheel **37** and a hundreds wheel **38**. Units wheel **36** is connected to shaft **16** whereby rotation of input gear **19** causes rotation of units wheel **36**. Each full rotation of units wheel **36** in either direction effects a one-tenth rotation of tens wheel **37** through a standard transfer mechanism **39** which is mounted on a shaft **41**. Shaft rotating means **29, 31, 32,** and **33** are herein disclosed in more detail as segmental gears including narrow kicker teeth and wide blocking teeth which engage corresponding segmental gears on the counter wheels.

Units wheel **36** consists of a number wheel **36***a* having the numbers 0–9 evenly indexed on the periphery thereof, and a predetermining wheel **36***b* of smaller diameter concentrically attached thereto. Shaft rotating means **29** adjacent units wheel **36** includes a plurality of wide blocking teeth such as **77** and a plurality of narrow kicker teeth such as **81**. Blocking teeth such as **77** normally ride the periphery of predetermining wheel **36***b* to prevent spurious rotation of output shaft **28**. When output shaft **28** is rotated, the blocking teeth mesh with a notch or recess in the periphery of predetermining wheel **36***b* as indicated at **44**. Kicker teeth such as **81** lie outside the periphery of predetermining wheel **36***b* and are adapted to engage with a segmental gear on the predetermining wheel such as **45**. The details of units wheel **36** are more fully disclosed in FIGURES 6*a* and 6*b*. In FIGURE 6*b* it can be seen that the predetermining wheel **36***b* forms a cylindrical surface adjacent number wheel **36***a* upon which the blocking teeth normally ride. Notch **44** is seen as extending the full width of the periphery of predetermining wheel **36***b* to accommodate the blocking tooth during rotation of the output shaft. The gear segment **45** on predetermining wheel **36***b* which engages with the kicker teeth on the output shaft is made up of a number of cog members which extend outwardly from the side of the predetermining wheel parallel to the central axis of the wheels. A similar cylindrical surface **46** on the opposite side of units wheel **36** acts as a blocking surface for transfer mechanism **39** and a pair of gear teeth **48** also co-act with the transfer mechanism.

From FIGURE 1 it can be seen that shaft rotating means **31** and **32** each mesh with driving means on tens wheel **37**. In FIGURE 5*a*, the side of tens wheel **37** adjacent hundreds wheel **38** is disclosed as including a large diameter number wheel **37***a* having a smaller diameter predetermining wheel **37***b* concentrically attached thereto. Once again, predetermining wheel **37***b* forms a blocking surface upon which the blocking teeth in shaft rotating means **32** ride. A notch or recess **50** is again provided in the surface of the predetermining wheel to accommodate the blocking teeth during rotation of the output shaft. Mounted on predetermining wheel **37***b* adjacent notch **50** are a pair of cog members **51** and **52** which extends out from the side of the wheel in a direction parallel to the common axis. A different view of this structure is disclosed in FIGURE 5*c*.

In FIGURE 5*b*, the side of tens wheel **37** adjacent units wheel **36** is disclosed. A predetermining wheel **37***c* of smaller diameter is again concentrically attached to number wheel **37***a*. As more clearly disclosed in FIGURE 5*c*, a pair of notches **53** and **54** are formed in the periphery of predetermining wheel **37***c* to accommodate the associated blocking teeth. Four cog members **56, 57, 58,** and **59** again extend from the side of the predetermining wheel adjacent the recesses to engage the kicker teeth on associated shaft rotating means **31**. Also formed in the periphery of predetermining wheel **37***c* are a plurality of gear teeth such as **61** which do not engage either the kicker teeth or the blocking teeth on the output shaft. Gear teeth **61** are adapted to engage with transfer means **39** to provide a tens transfer between units wheel **36** and tens wheel **37**.

Operation

Referring now to FIGURE 3, there is disclosed a schematic diagram of the counter wheels with the output shaft shown in the different positions assumed during a full range of rotation of the counter wheels. Five distinct positions of the output shaft are shown in the drawing with the top position and the bottom position being the same. The output shaft rotates 72° between positions thus assuming all of the positions during a full rotation. It should first be noted that this particular counter has a range from 000 to 199. The units wheel is driven by the output from the differential and its movement is transferred to the tens wheel through standard transfer mechanism **39**. The movement of the hundreds wheel is not effected directly through a standard transfer mechanism but is provided through rotation of the output shaft. The hundreds wheel is thus driven by the output shaft while the units wheel and the tens wheel drive the output shaft. The hundreds wheel merely acts as an indicator in this application and has no other function. For purposes of illustration, the numbers on the wheels have been placed on the side of each wheel rather than on the periphery. The circle which surrounds a number on each wheel is meant to represent the readout position for the counter. The counter in FIGURE 3 is thus set to 158. The readout position remains in the same position during rotation while the wheels rotate the other numbers through that position. As is well known in the counter art, the positioning of the numerals on the wheels is a relative thing dependent upon the desired readout position.

Assume that the wheels have been set to 158 as shown on the drawing and that the munition has been launched. The input device drives the units wheel in a counterclockwise direction to begin the countdown. The units wheel completes one revolution every ten seconds and the tens wheel makes a complete revolution every one hundred seconds. A partial rotation of the output shaft is desired when the counter reaches the zero position. Because of the fact that the units wheel is continuously rotating, shaft rotating means **29** cannot be placed in position to mesh with the corresponding segmental gear **45** until the final rotation of the units wheel from 009 to 000.

The position of the output shaft marked "A" in FIGURE 3 is that position corresponding to the high range of the counter from 100 to 199. For purposes of interpretation of the diagram, the wide teeth shown on the drawing represent the blocking teeth which ride the periphery of the corresponding predetermining wheel to prevent spurious rotation of the output shaft. The narrow teeth represent kicker teeth which lie in a plane parallel to the outer surface of the predetermining wheel in line to be contacted by the associated cog members extending outwardly from the side of the wheel. Shaft rotating means **32**, for example, includes a pair of wide blocking teeth and a single kicker tooth. In position "A" of output shaft **28**, the two blocking teeth **66** and **67** are in position to ride the periphery of predetermining wheel **37***b*. Output shaft **28** cannot rotate in either direction since blocking teeth **66** and **67** cannot pass through the surface of the predetermining wheel. Kicker tooth **68** lies adjacent the predetermining wheel **37***b* and extends below the periphery thereof. Upon rotation of tens wheel **37** to the proper position, either cog member **51** or cog member **52** will mesh with kicker tooth **68** to effect rotation of output shaft **28**.

Shaft rotating means **31** includes three blocking teeth **69, 70,** and **71**, and single kicker tooth **72**. In position "A" of output shaft **28**, blocking teeth **70** and **71** prevent rotation of the output shaft but kicker tooth **72** is out of position to be contacted by the associated cog members on predetermining wheel **37***c*.

Shaft rotating means **29** includes four blocking teeth **75**, **76**, **77**, and **83**, and four kicker teeth **80**, **81**, **82**, and **84**. In position "A" of output shaft **28**, blocking teeth **76** and **77** ride the periphery of predetermining wheel **36***b* to assist in preventing spurious rotation of output shaft **28**. None of the kicker teeth on shaft rotating means **29** are in position to be contacted by the associated cog members on predetermining wheel **36***b*.

During the countdown from 158 to 000, the first 72° of output shaft rotation occurs when the counter reaches 100. During the transfer from 100 to 099, predetermining wheel **37***b* attached to the rear (hundreds-wheel side) of the tens wheel is the driving wheel for the output shaft. As tens wheel **37** passes from 0 to 9 in a countdown direction, cog member **52** contacts kicker tooth **68** to initiate rotation of the output shaft. Blocking tooth **67** meshes with recess **50** in the periphery of predetermining wheel **37***b* to complete the 72° of rotation. At the same time, blocking tooth **70** on the other side of the tens wheel is meshing with recess **53** in the periphery of predetermining wheel **37***c*. Blocking tooth **76** adjacent the units wheel also meshes with recess **44** on predetermining wheel **36***b*.

As the counter reaches 099 then, output shaft **28** has assumed the position labelled "B" on the drawing. During this clockwise rotation of the output shaft from position "A" to position "B," hundreds wheel **38** is also rotated 36° in a counter clockwise direction to remove the numeral 1 from the readout position. The plurality of teeth on shaft rotating means **33** merely provide a normal gear transfer with corresponding gear teeth on hundreds wheel **38**. A single wide tooth **86** is used to mesh with a pair of recesses **87** and **88** in the periphery of hundreds wheel **38** to assure that the hundreds wheel is positioned correctly with respect to the remaining wheels. In this particular application, the hundreds wheel is merely an indicator and performs no driving function with respect to the output shaft.

Position "B" of output shaft **28** corresponds to the middle range of numbers on the counter between 099 and 010. During the time that the counter is in the middle range, output shaft **28** is locked in position by the blocking teeth. Blocking teeth **67**, **70**, and **76** prevent rotation of output shaft **28** in a counterclockwise direction while blocking teeth **69** and **75** prevent rotation in a clockwise direction. In position "B," only one kicker tooth is again in position to be contacted by an associated cog member as the counter leaves the middle range. Kicker tooth **72** hangs down adjacent the side of predetermining wheel **37***c* to be contacted by cog member **59** as the wheel goes from 1 to 0 in a countdown direction or by cog member **56** as the wheel goes from 9 to 0 in a forward direction. As the counter goes from 010 to 009 in a countdown direction, cog member **59** contacts kicker tooth **72** to initiate rotation of output shaft **28**. Blocking tooth **69** meshes with recess **54** in the periphery of predetermining wheel **37***c* to complete 72° of rotation of output shaft **28**. During this movement of the output shaft from position "B" to position "C," blocking tooth **75** adjacent the units wheel meshes with recess **44** as the units wheel goes from 0 to 9.

If, during the time that the counter was in the middle range corresponding to position "B" on the output shaft, the counter had been reversed and driven in a forward direction, the output shaft would have been returned from position "B" to position "A" as the counter rotated from 099 to 100. Once again kicker tooth **72** would have been contacted, this time by cog member **56**, and blocking tooth **70** would have meshed with recess **53**. During this rotation from position "B" to position "A," blocking tooth **67** would have meshed with recess **50**, and blocking tooth **76** would have meshed with recess **44**. Shaft rotating means **33** would also have moved the hundreds wheel back to the original position with the numeral 1 showing at the readout position.

After the rotation from 010 to 009 is complete, the output shaft assumes the position "C" on the diagram. In this position, blocking teeth **69** and **75** prevent rotation of output shaft **28** in a counterclockwise direction. Tooth **83** adjacent the units wheel has been constructed as a semi-blocking tooth to prevent clockwise rotation. Tooth **83** has a width intermediate between that of the blocking teeth and the kicker teeth. This can be more clearly seen in FIGURE 1 and FIGURE 7. A recess **47** of similar width has been formed in the periphery of predetermining wheel **36***b* as disclosed in FIGURE 6*b*. Recess **47** does not extend the full width of the periphery of the predetermining wheel but it is sufficiently large to accommodate semi-blocking tooth **83**. The reason that tooth **83** was not made a full width blocking tooth is as follows. During the rotation of the counter from 099 to 100, and the output shaft from position "B" to position "A," blocking tooth **77** is rotated firmly against the periphery of predetermining wheel **36***b* just prior to the time that recess **47** passes beneath it. If recess **47** were of full width, there is a possibility that the inertial effects of the high speed rotation might cause blocking tooth **77** to partially engage recess **47**. By reducing the width of recess **47**, this possibility of jamming the counter is avoided. In position "C" then, tooth **83** acts as a blocking tooth to prevent spurious rotation of output shaft **28** in a clockwise direction.

Position "C" of output shaft **28** corresponds to the low range of the counter. Kicker tooth **84** is now in position to be contacted by an associated cog member and no other kicker tooth is in such a position. If the counter were stopped and the direction of rotation reversed to a forward direction, kicker tooth **84** would be engaged by the leading cog member on predetermining wheel **36***b* as it rotated in a clockwise direction, and blocking tooth **75** would mesh with recess **44** to return the output shaft to position "B." Once again, blocking tooth **69** would engage recess **54** in predetermining wheel **37***c*.

It should be noted that positions "D" and "E" of output shaft **28** as well as position "C" correspond to the low range of the counter. The reason for this is that a more accurate output can be obtained from the output shaft if it is rotating through the position at the time an output is desired. By picking up the output shaft two seconds ahead of the desired output time, a smooth rotation of the output shaft is achieved and backlash errors minimized. It is more accurate to trigger a firing device by moving the sear smoothly through the firing point than to fire the device at the beginning or end of movement of the sear. In this application, an arming device is released as the counter passes through 001, and the device is fired as the counter passes through 000; both events occurring while the shaft is in motion.

The transfer of output shaft **28** from position "C" to position "D" occurs as the counter passes from 002 to 001. The rotation from position "D" to position "E" occurs as the counter passes from 001 to 000, and the output shaft is returned to position "A" as the counter moves from 000 to 199. Output shaft **28** is thus rotated continuously through 216 degrees as the counter moves from 002 to 199 in a countdown direction. The plurality of teeth on shaft rotating means **29** engage with corresponding cog members on predetermining wheel **36***b* during this period to drive the output shaft. The remaining wheels and shaft rotating means merely follow along in order to retain relative positions. The accuracy of the final output is thus dependent only upon the accuracy with which the transfer from the units wheel is made to the output shaft. If at any time during this period, the counter should be stopped and reversed, the output shaft would reverse with it and would rotate in the opposite direction to retain the correct position with respect to the position of the counter wheels.

It should be understood that the so-called blocking teeth on the output shaft perform three different functions in this device.

First: The blocking teeth, as blocking teeth, prevent spurious rotation of the output shaft by riding on the blocking surfaces of the counter wheels.

Second: The blocking teeth, as gear teeth, in cooperation with the kicker teeth, swing the output shaft through its intermittent motions by meshing with the notches in the couner wheel blocking surfaces.

Third: Some blocking teeth in this device, as checking teeth, act as counter wheel position interlocks by meshing simultaneously into the blocking surface notches of two or more counter wheels to insure that the counter wheels are not incorrectly assembled.

A careful consideration of FIGURE 3 will reveal the many virtues of this invention. For each position of the counter wheel there is a predictable output shaft position. During the time that the output shaft is not moving, it is locked in position by the blocking teeth. The shaft cannot be moved from a fixed position until the counter wheels drive the shaft to a new position in which it is again locked. The counter will count through zero in either a forward or a countdown direction and the output shaft will follow it accurately. The counter can be stopped at any point and reversed without fear of jamming the mechanism. In other applications as well as in this particular application, it may be desirable to utilize the intermediate partial rotations of the output shaft to perform useful work. In a fluid flow application, for example, the final output may be utilized to close a valve to stop the fluid flow. In such a case, the intermeidate rotations could be used to partially close the valve so that the full flow need not be stopped suddenly at the final output.

In this particular embodiment of the invention, only two of the counter wheels are used to drive the output shaft. The hundreds wheel is merely an indicator and has no driving function. This was done to increase the accuracy of the counter and to reduce the possibility of jamming the counter and output shaft gears. The gears on the output shaft are firmly fixed in their relative positions but the gears on the counter wheels will have a relationship only as accurate as the accuracy of the transfer mechanism between the wheels. There is always some problem with backlash or lost motion caused by inaccuracies in the transfer mechanism between the wheels. For each transfer this inaccuracy is multiplied. In this application, only one transfer between the driving wheels is needed, therefore reducing the amount of lost motion between wheels. In the case of the counter passing from 100 to 099, for example, three blocking teeth must simultaneously pass through corresponding recesses in different predetermining wheels. Even a small amount of inaccuracy of motion between the wheels would cause one of the blocking teeth to miss accurate meshing with its corresponding recess.

It should again be observed that the theory of operation described herein is applicable to a counter having either more or less than the number of wheels described in the preferred embodiment. Neither is there any magic in the 72° of rotation each time the shaft is moved. It would be a matter of engineering in each case to determine the number of teeth required on the output shaft, the number of corresponding teeth and recesses on the wheels, and the number of degrees of rotation required for each movement of the output shaft.

An enlarged view of the output shaft utilized in the preferred embodiment is disclosed in FIGURE 7. The exact angular relationship existing between the kicker teeth and blocking teeth on each of the wheels, and the relationship existing between the different groups of gears can be seen by examining FIGURES 8, 9, 10, and 11. The top tooth in each of FIGURES 8, 9, 10, and 11 is located at the same angular position on the shaft.

Refer again to FIGURE 1. The counter has been set to read approximately 197 if the readout is taken from a readout position outlined at **15**. The position of output shaft **28** thus corresponds to position "A" in FIGURE 3. If the counter is rotated in a clockwise direction as viewed from support member **12**, the rotation will be in a forward direction and the counter will soon move from 199 to 000 and the output shaft will rotate to position "E" as shown in FIGURE 3. During the rotation of the counter from 199 to 000, kicker tooth **68** will be contacted by cog member **51**, and blocking tooth **66** will mesh in recess **50**. Blocking tooth **71** will mesh with recess **53**, and blocking tooth **77** will mesh with recess **44**. The fact that the numerals on the wheels in FIGURE 1 are placed in a different relative position with respect to the gear teeth on the predetermining wheels as compared to the number positions in FIGURE 3 is due to the fact that the readout in FIGURE 3 is taken from a position directly adjacent the output shaft while the readout position in FIGURE 1 is offset from the output shaft.

In a broader sense, the embodiments previously described herein all utilize a common method of obtaining an output from a predetermining counter and of automatically resetting the counter. Using this method, it is possible to provide a programmed output from the counter at any desired reading on the counter and to make this output automatically resettable and repeatable. The desired result and the problems to be faced must be kept in mind. The output is normally taken from the lowest order wheel since it is indexed in terms of the lowest unit of the quantity to be measured. The problem, then, is that the lowest order wheel will revolve through the desired output position many times before the output is desired. To solve this problem, the movement of the higher order wheels is monitored and utilized to predict the arrival of the lowest order wheel at the desired revolution. An output is then taken from the lowest order wheel at a selected position in the revolution; and the movement of each lower order wheel through either limit of the revolution in which the output is desired is utilized to reset the output mechanism.

A specific example will clarify the method. Assume that a standard three wheel decadal counter is used which counts in either direction from 000 to 999. Assume that an output from the counter is desired each time the counter passes through position 136.5. The output must be taken when the hundreds wheel is stopped at 1, the tens wheel is stopped at 3, and the units wheel is passing through 6.5. Note again that between 000 and 999, the units wheel will pass through position 6.5 a total of 100 times; the tens wheel will pass through position 3 a total of 10 times; and the hundreds wheel will pass once through position 1. Also note, however, that during the time that the hundreds wheel is in position 1, the tens wheel will pass through position 3 only once; and during the time that the hundreds and tens wheels read 13, the units wheel will pass through position 6.5 only once. This is true whether the counter is being rotated in a forward or in a reverse direction. This relationship can be used to provide an output at 136.5. A first output device is used to detect the rotation of the hundreds wheel to position 1 in either direction. The first output is used to place a second output device in position to detect the rotation of the tens wheel to position 3. The second output is used to place a final output device in position to detect the rotation of the units wheel through position 6.5. The final output can be used to perform useful work. The output devices are automatically reset as follows. During the time that the hundreds and tens wheel read 13, the units wheel can make one revolution without changing the reading to 12 or 14. The final output device is in position during this time to detect the movement of the units wheel through 6.5. If the units wheel moves through either of the limits of the revolution to change the higher wheels to either 12 or 14, an output is no longer desired at 6.5 but the second output device must be reset so as to respond if the tens wheel returns to position 3. The final output device is thus

designed to detect the movement of the units wheel through either of the limits to reset the second output device. With the second output device reset, a return of the tens wheel to position 3 will generate an output to again reset the final output device.

During the time that the hundreds wheel is at position 1, the tens wheel can make one revolution without changing the hundreds wheel to position 0 or 2. The movement of the tens wheel can thus be used to predict the point at which the hundreds wheel will transfer to 0 or 2. The second output device is thus designed to detect the movement of the tens wheel through either of its limits to transfer the hundreds wheel to 0 or 2. This movement is used to reset the first output device such that it will respond to the return of the hundreds wheel to position 1.

In this particular example, the outputs would occur at the following numbers if the wheels were rotated from 999 to 000 in a countdown direction: 200–199; 140–139; 137–136; 130–129; 100–099. (The underlined numbers represent the wheel from which the output is being taken.) If the counter were rotated from 000 to 999 in a forward direction, the outputs would occur as follows: 099–100; 129–130; 136–137; 139–140; 199–200. No further movements are necessary to obtain the final output or to make the counter and output mechanism fully reversible.

From the preceding description it should be apparent that I have invented a unique automatically resettable output device for a predetermining counter. Although the form of the invention described herein constitutes a preferred embodiment, it will be understood that changes may be made within the spirit of the invention limited only by the scope of the appended claims.

I claim as my invention:

1. A predetermining counter capable of continuous forward or reverse counting from 000 to 199, comprising: a succession of different order counter wheels mounted for individual rotation on a common axis and including a units wheel, a tens wheel and a hundreds wheel; means for rotating said units wheel; tens transfer means connecting said units wheel to said tens wheel; said units wheel and said tens wheel each having the numerals 0–9 evenly indexed around the periphery thereof; said hundreds wheel having the numeral 1 indexed at one or more selected points on the periphery thereof; said units wheel having a first predetermining wheel of smaller diameter concentrically attached thereto; said tens wheel having second and third predetermining wheels of smaller diameter concentrically attached to either side thereof; said predetermining wheels each having a first notch formed in the periphery thereof; a first pair of cog members attached to an outer side of each of said predetermining wheels flanking said notch and extending therefrom parallel to said common axis; a rotatable output shaft mounted adjacent the periphery of said counter wheels and parallel to said common axis; said output shaft having at least one kicker tooth affixed thereto adjacent each of said predetermining wheels lying in a plane parallel to said outer side of the associated predetermining wheel and said plane intersecting said cog members; said output shaft having a first position with said kicker tooth of said third predetermining wheel lying in the path of said associated cog members, and said lower order kicker teeth being mounted on said output shaft out of the path of said lower order cog members; one of said third predetermining wheel cog members contacting said kicker tooth upon rotation of said counter wheels from 199 to 000 or from 100 to 099 to thereby cause partial rotation of said output shaft to place a lower order kicker tooth in line with a lower order cog member; said second predetermining wheel having a second pair of cog members flanking a second notch in the periphery thereof; one of said second predetermining wheel cog members contacting said associated kicker tooth upon the rotation of said counter wheels from 099 to 100 or from 010 to 009 to rotate said shaft and place either a higher or a lower order kicker tooth respectively in position to be contacted; said first predetermining wheel having a second pair of cog members and a third pair of cog members mounted adjacent said first pair of cog members; said output shaft having a plurality of kicker teeth mounted thereon adjacent said first predetermining wheel designed to mesh with said cog members to effect rotation of said output shaft when said counter rotates from 002 to 001, from 001 to 000, or from 000 to 199 in a countdown direction, and from 000 to 001, from 001 to 002, or from 009 to 010 in a forward direction; at least one blocking tooth associated with each of said predetermining wheels; said blocking teeth being mounted on said output shaft and adapted to ride the periphery of said associated predetermining wheel to prevent spurious rotation of said output shaft; said blocking teeth each meshing with a notch in the corresponding predetermining wheel to aid said corresponding kicker tooth in rotating said output shaft; and a plurality of gear teeth mounted on said output shaft adapted to mesh with corresponding teeth on said hundreds wheel to effect rotation thereof in accordance with the movements of the lower order wheels.

2. A predetermining counter capable of continuous forward or reverse counting, comprising: a succession of different order counter wheels mounted for individual rotation on a common axis and including a units wheel, a tens wheel and a hundreds wheel each having appropriate numerals indexed on the periphery thereof; means for rotating said units wheel; transfer means connecting said units wheel to said tens wheel; said units wheel having a first predetermining wheel concentrically attached thereto; said tens wheel having second and third predetermining wheels concentrically attached to either side thereof; said predetermining wheels each having a first notch formed on the periphery thereof; a pair of cog members attached to an outer side of each of said predetermining wheels flanking said notch and extending therefrom parallel to said common axis; a rotatable output shaft mounted adjacent the periphery of said counter wheels and parallel to said common axis; said output shaft having at least one kicker tooth affixed thereto adjacent each of said predetermining wheels and rotatable with said shaft in a plane parallel to said outer side of the associated predetermining wheel and said plane intersecting said cog members; said output shaft having a first position corresponding to a first preselected range of positions on said counter wheels with said kicker tooth of said third predetermining wheel lying in the patch of said associated cog members, and said lower order kicker teeth being mounted on said output shaft out of the path of said lower order cog members; one of said third predetermining wheel cog members contacting said kicker tooth upon rotation of said counter wheels through either a high or a low limit of said first range to thereby cause partial rotation of said output shaft to place a different order kicker tooth in position to be contacted by a corresponding cog member; said second predetermining wheel having a second pair of cog members flanking a second notch in the periphery thereof; one of said second perdetermining wheel cog members contacting said associated kicker tooth upon the rotation of said counter wheels through either a high or low limit of a second preselected range of positions adjacent said first range on said counter wheels to rotate said shaft and place another kicker tooth in position to be contacted; said first predetermining wheel having a second pair of cog members and a third pair of cog members mounted thereon adjacent said first pair of cog members; said counter wheels having a third range of positions including all positions not encompassed by said first and second ranges; said output shaft having a plurality of kicker teeth mounted thereon adjacent said first predetermining wheel adapted to mesh with said cog members to effect rotation of said output shaft when said

counter rotates through selected positions within said third range or rotates through either a high or a low limit of said third range; the rotation of said counter through the low limit of said third range into said first range causing said output shaft to rotate to said first position; at least one blocking tooth associated with each of said predetermining wheels; said blocking teeth being mounted on said output shaft and adapted to ride the periphery of said associated predeterminng wheel to prevent spurious rotation of said output shaft; said blocking teeth each meshing with a notch in the corresponding predetermining wheel to aid in rotating said output shaft; and a plurality of gear teeth mounted on said output shaft adapted to mesh with corresponding teeth on said hundreds wheel to effect rotation thereof in accordance with the movements of the lower order wheels.

3. A predetermining counter capable of continuous counting in either direction from a 0 position to a preselected maximum number having 3 digits, comprising: a succession of different order counter wheels mounted for individual rotation on a common axis and including a units wheel, a tens wheel and a hundreds wheel each having appropriate numerals indexed on the periphery thereof; means for rotating said units wheel; means for transferring the rotation of said units wheel to said high order wheels; said counter having a total range of positions including 0 through the preselected number having 3 digits; said total range being sub-divided into 3 ranges with the first lowest range having a low limit of 0 and a high limit equivalent to the highest number displayable by said units wheel, the second range having a low limit one position above the high limit of the first range and a high limit equivalent to the largest number displayable by the tens wheel and the units wheel, the third range having a low limit one position above the high limit of the second range and a high limit equivalent to the maximum number displayable by the three counter wheels; shaft rotating means attached to said output shaft adjacent said units wheel; driving means on said units wheel engageable with said shaft rotating means to cause partial rotation of said shaft when said counter rotates through selected positions within said first range or rotates through either the high or low limit of said first range; further separate shaft rotating means associated with each of said higher ranges and engageable by separate driving means mounted on at least one of said higher order wheels; said further shaft rotating means being mounted on said output shaft such that a partial rotation of said output shaft is achieved by engagement with associated driving means each time said counter passes through either limit of either of said higher ranges; said individual shaft rotating means being placed in position to be engaged by the associated driving means by the partial rotation of said shaft during the movement of the counter through the adjoining limit of the adjoining range; the rotation of said counter through the full range thereby causing one full rotation of said output shaft; and means attached to said output shaft to prevent spurious rotation thereof.

4. A predetermining counter capable of continuous counting in either direction from a 0 position to a preselected maximum number having N digits, comprising: a succession of N different order counter wheels mounted for individual rotation on a common axis and including a units wheel and N minus one higher order wheels each having appropriate numerals indexed on the periphery thereof; means for rotating said units wheel; means for transferring the rotation of said units wheel to said higher order wheels; said counter having a total range of readout positions including 0 through the selected number having N digits; the total range being sub-divided into N ranges with the first lowest range having a low limit of 0 and a high limit equivalent to the highest number displayable by said units wheel, each higher range including the Nth range having a low limit one position above the high limit of the next lower range and a high limit equivalent to the maximum number displayable by the corresponding number of counter wheels; a rotatable output shaft mounted adjacent said counter wheels; shaft rotating means attached to said output shaft adjacent said units wheel; driving means on said units wheel engageable with said shaft rotating means to provide partial rotation of said shaft when said counted rotates through selected positions within said first range or rotates through either the high or low limit of said first range; and further shaft rotating means associated with each of said higher ranges and engageable by separate driving means mounted on corresponding higher order wheels; said further shaft rotating means being mounted on said output shaft such that a partial rotation of said output shaft is achieved by engagement with said driving means each time said counter passes through either limit of any of said ranges; each of said individual shaft rotating means being rotated into position for engagement by the associated driving means by the partial rotation of said shaft caused by the movement of said counter through the adjacent limit of the adjoining range.

5. A predetermining counter capable of continuous counting in either direction from a 0 position to a preselected maximum number having N digits, comprising: a succession of N different order counter wheels mounted for individual rotation on a common axis and including a units wheel and N minus one higher order wheels each having appropriate numerals indexed on the periphery thereof; means for rotating said units wheel; means for transferring the rotation of said units wheel to said higher order wheels; said counter having a total range of positions including 0 through the selected number having N digits; the total range being sub-divided into N ranges with the first lowest range having a low limit of 0 and a high limit equivalent to the highest number displayable by said units wheel, the Nth range having a low limit one position above the high limit of the N minus 1 range and a high limit equivalent to the preselected number displayable by N counter wheels; N individual output means each corresponding to one of said ranges mounted adjacent said counter wheels at a reference position; N individual driving means each corresponding to one of said output means mounted on said wheels for rotation through said reference position; each of said output means having a first position in line for engagement with an associated driving means, and a plurality of alternate positions out of line with said driving means; said driving means being positioned on said wheels such that at least one driving means passes through said reference position each time said counter passes through either of the limits of said ranges; and means for connecting said individual output means in a fixed relative relationship such that each output means is in said first position when said counter wheels are in said corresponding range and in an alternate position with said counter wheels in any other range; said driving means corresponding to each range engaging said corresponding output means upon said counter passing through either of the limits of said range to thereby provide an output and move an adjoining output means into said first position.

6. A predetermining counter capable of continuous counting in either direction from a 0 position to a preselected maximum number having 3 digits, comprising: a succession of different order counter wheels mounted for individual rotation on a common axis and including a units wheel, a tens wheel and a hundreds wheel each having appropriate numerals indexed on the periphery thereof; means for rotating said units wheel; means for transferring the rotation of said units wheel to said high order wheels; said counter having a total range of positions including 0 through the preselected number having 3 digits; said total range being sub-divided into 3 ranges with the first lowest range having a low limit of 0 and a high limit equivalent to the highest number displayable by said units wheel, the second range having a low limit one position

above the high limit of the first range and a high limit equivalent to the largest number displayable by the tens wheel and the units wheel, the third range having a low limit one position above the high limit of the second range and a high limit equivalent to the highest number displayable by the three counter wheels, first, second and third output means corresponding to said first, second and third ranges respectively mounted adjacent said counter and each having a first position and a plurality of alternate positions; said output means being responsive to the movement of said counter through either of the limits of said corresponding first, second or third ranges when in said first position and non-responsive to the movement of said counter when in an alternate position; the response of said first, second and third output means being in the form of a movement from said first position to an alternate position; said first, second and third output means being mounted initially in a fixed relative relationship with only the one output means corresponding to the initial counter position being in said first position and said other output means being in an alternate non-responsive position; and means connecting said first, second and third output means to hold said output means in said fixed relative relationship; said fixed relative relationship being such that the movement of one output means from said first position to an alternate position caused by the movement of said counter from one of the ranges to another of the ranges will result in the movement of a different output means corresponding to the range into which said counter is moved from said alternate position to said first position and the movement of the remaining output means from one alternate position to another; each of said output means moving through the first position and all alternate positions during the rotation of the counter through the full range.

7. A predetermining counter capable of continuous counting in either direction from a zero position to a preselected maximum number having N digits, comprising: a set of N coaxially mounted operatively connected different order number wheels each having appropriate numerals indexed on the periphery thereof; means for rotating the lowest order counter wheel in either direction to set a predetermined number on said counter; means for rotating said lowest order wheel to drive said counter from said predetermined number to the zero position at which position an output is desired; said counter having a total range of digit reading positions equivalent in number to zero plus the selected number having N digits; the total range being sub-divided into N ranges with the lowest range having a low limit of zero and a high limit equivalent to the highest number displayable by said lowest order wheel, each of the remaining ranges having a low limit one position above the high limit of the next lower range and a high limit equivalent to the largest number displayable by the corresponding counter wheel and all lower order counter wheels; a rotatable output shaft mounted adjacent said counter wheels at a reference position with respect to the indexed periphery of said wheels; said output shaft having a plurality of rotated positions each corresponding to one of the ranges on said counter; said counter wheels having N segmental gears mounted thereon such that at least one of said segmental gears rotates through said reference position each time said counter rotates through a limit of one of the ranges; said output shaft having N longitudinally spaced apart segmental gears mounted at radially spaced apart positions thereon; said output shaft in each of said rotated positions having at least one segmental gear positioned for engagement with a corresponding gear on said counter wheels to provide a partial rotation of said shaft upon said counter wheel segmental gear rotating through said reference position; and said output shaft segmental gears being radially positioned such that the partial rotation of said shaft caused by the rotation of said counter from a first range to a second range moves the output shaft segmental gear corresponding to said second range into position to be engaged by the corresponding counter wheel segmental gear upon the rotation of said counter wheel through either of the limits of said second range; a full rotation of said output shaft being equivalent to the rotation of said counter through its full range.

8. An automatically resettable mechanism for generating an output from the lowest order wheel of a predetermining counter having a set of co-axially mounted operatively connected different order number wheels each having a zero position thereon, comprising: means for rotating the lowest order wheel in either a forward or a countdown direction to set said counter to a predetermined number; means for rotating said lowest order wheel in a countdown direction to drive said counter from said predetermined number setting to a reference setting with said zero positions aligned; first output means positioned adjacent said wheels for generating a first partial output from the movement of said highest order wheel to the reference setting in a countdown direction; second output means including means positioned by said first output means for generating a second partial output from the movement of the second highest order wheel to the reference setting for the last time in a countdown direction; a similar sequence of events occurring upon each of the higher order wheels reaching the reference position for the last time in a countdown direction; final output means including means positioned by the next higher output means for generating a final output during the final rotation to the reference position of said lowest order wheel; means for generating an output from the movement of said lowest order wheel through the reference position for the last time in a countdown direction to place said first output means in position to produce a first partial output; and means for successively resetting said output means during movement of said counter from said reference setting to said predetermined number setting in a forward direction; the resetting of each output means by the next lower output means occurring during the movement of each wheel to the zero position for the first time in a forward direction.

9. An automatically resettable mechanism for generating a timed output from the lowest order wheel of a predetermining counter having a set of co-axially mounted operatively connected different order number wheels each having a zero position thereon, comprising: a mechanical differential having first and second input shafts and an output shaft; a setting knob connected to the first input shaft; means connecting said output shaft to the lowest order wheel to rotate the lowest order wheel in either a forward or a countdown direction to set the counter to a predetermined number upon rotation of the setting knob; a timing device connected to the second input shaft to rotate the lowest order wheel in a countdown direction at a predetermined speed to drive the counter from the predetermined number setting to a reference setting with the zero positions aligned; first output means positioned adjacent the counter to generate a first partial output from the movement of the highest order wheel to the referenced setting in a countdown direction; second output means including means positioned by the first output means for generating a second partial output from the movement of the second highest order wheel to the reference setting for the last time in a countdown direction; a similar sequence of events occurring upon each of the higher order wheels reaching the reference position for the last time in a countdown direction; final output means including means positioned by the next higher order output means for generating a final output during the final rotation to the reference position of the lowest order wheel; means to generate an output from the movement of the lowest order wheel through the reference position for the last time in a countdown direction to place the first output means in position to produce a first partial output; and

means for successively resetting said output means during movement of the counter from the reference setting to the predetermined number setting in a forward direction; the resetting of each output means by the next lower order output means occurring during the movement of each wheel to the zero position for the first time in a forward direction.

10. In combination with a reversible multiple wheel counter having a set of operatively connected different order number wheels, means for generating an output at a preselected number position, comprising a first output device to detect the movement of the highest order wheel to the first digit of the preselected number from either direction; and to thereupon generate a first output indicative of the arrival of the counter at the broad range of numbers having the same first digit as the preselected number; a second output device positioned by said first output to detect the movement of the second highest order wheel to the second digit of the preselected number to thereupon generate a second output indicative of the arrival of the counter at the range of numbers having the same first and second digits as the preselected number; said second output positioning further output devices associated with lower order wheels in similar sequential fashion until a final output is generated upon the movement of all of the wheels to the preselected number position; means associated with each of the second and lower output means to detect the particular movement of the associated counter wheel which indicates that the next higher wheel is moving from the preselected number position to a higher or lower number position; and means for utilizing the particular movement to position the next higher output means to respond to subsequent movement of the next higher order wheel.

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LEO SMILOW, *Primary Examiner.*