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Haydon

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[45] **Nov. 11, 1975**

[54] **DIGITAL CLOCK OR OTHER COUNTING DEVICE WITH RESILIENT COUPLING MEANS IN THE DRIVE TRAIN**

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[73] Assignee: **Tri-tech, Inc.**, Waterbury, Conn.

[22] Filed: **Mar. 6, 1974**

[21] Appl. No.: **448,749**

[52] **U.S. Cl.** ..... **58/125 C**; 58/126 E; 235/133

[51] **Int. Cl.**[2] **G04B 19/02**; G04B 19/00; G06C 15/26

[58] **Field of Search** ..... 74/409, 142, 209; 310/74, 310/75 D, 49, 172; 235/117, 136, 1 C, 144 MA, 133, 134, 142; 64/15 R, 15 C; 58/125 C, 126 E, 7, 48

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Primary Examiner—Joseph W. Hartary
Assistant Examiner—U. Weldon
Attorney, Agent, or Firm—Lee C. Robinson, Jr.

[57] **ABSTRACT**

A digital clock or other counting device in which the output shaft on the drive motor of the device is resiliently connected to the gear train by means of a spiral spring. The drive motor is of the stepper motor type and applies energy to the spring in discrete increments. During the initial portion of each increment, the gear train remains stationary, and it then gradually accelerates and continues its movement after the motor shaft has come to rest. The arrangement is such that there is a very smooth and quiet transfer of energy from the shaft through the gear train to the individual counting elements. In some embodiments the counting elements comprise register drums in which motion is transferred between certain of the drums by a Geneva type transfer pinion assembly and between other drums by resiliently biased planetary gearing.

9 Claims, 8 Drawing Figures

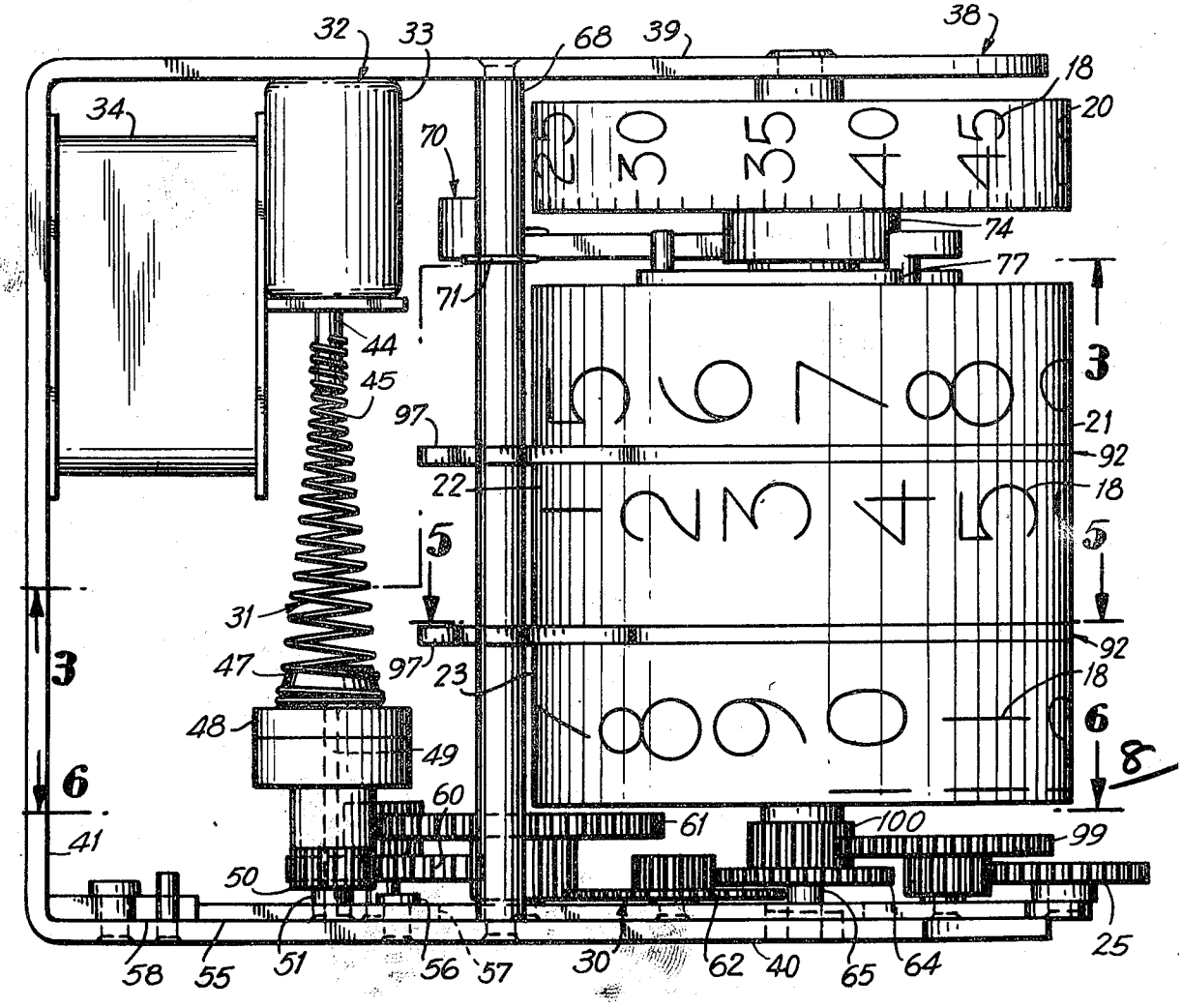


FIG. 1

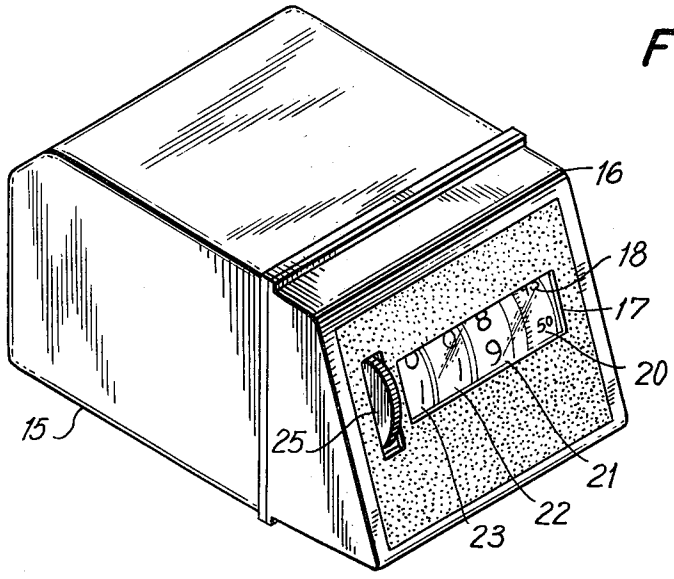
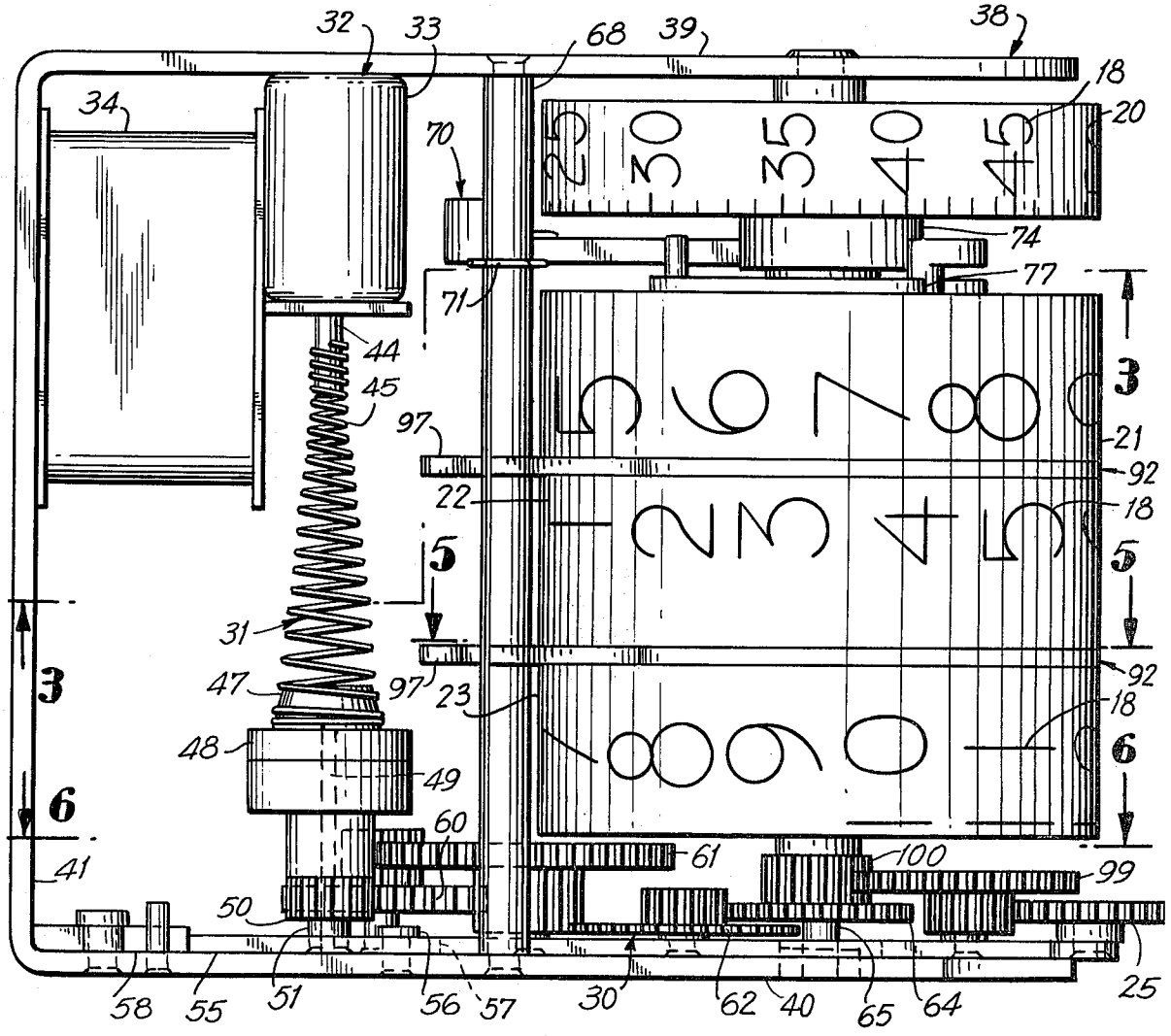

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FIG. 2


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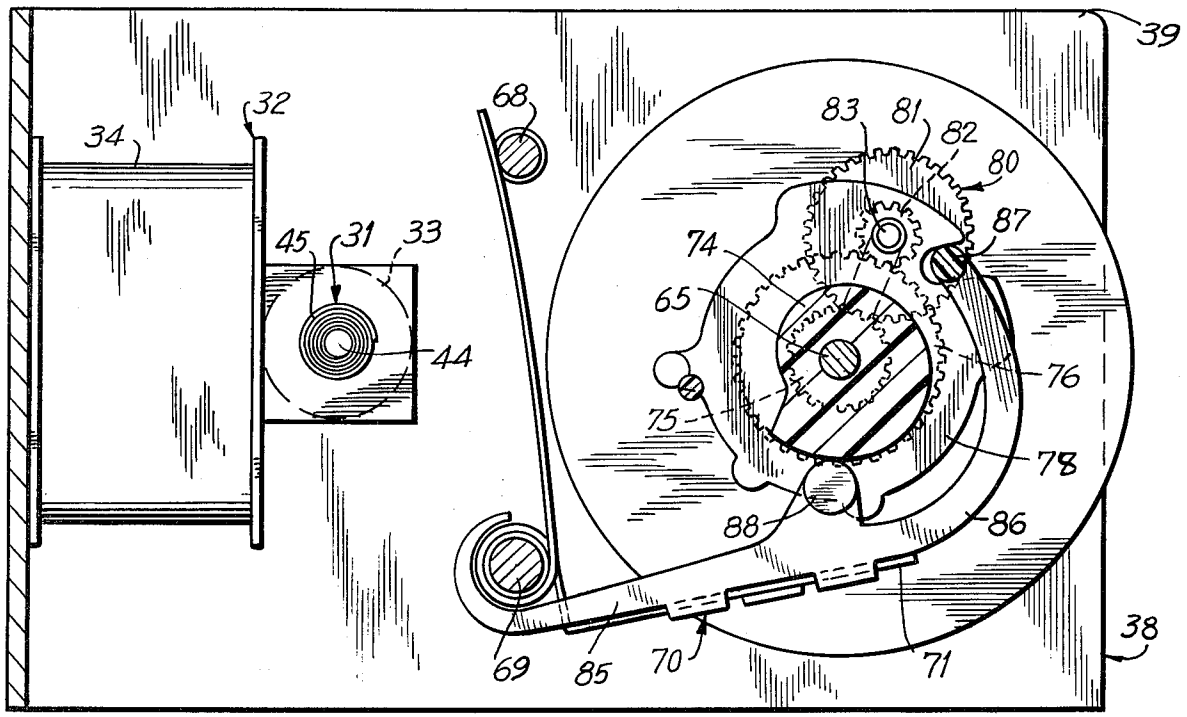

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FIG. 3

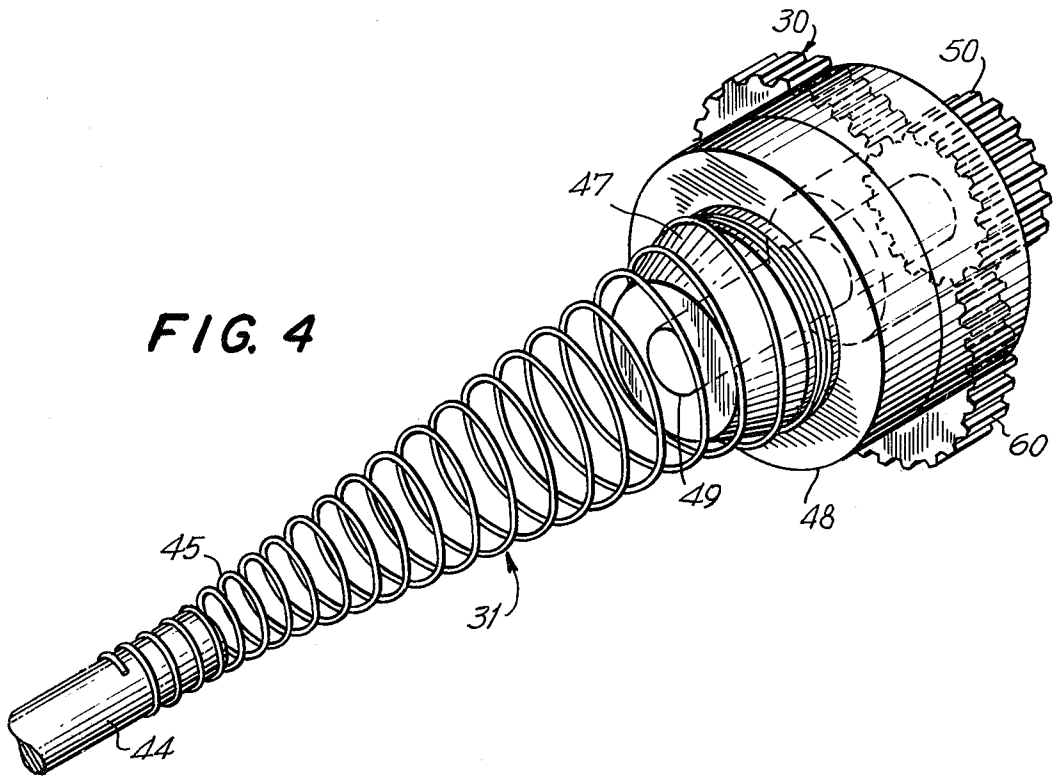

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FIG. 4

FIG. 5

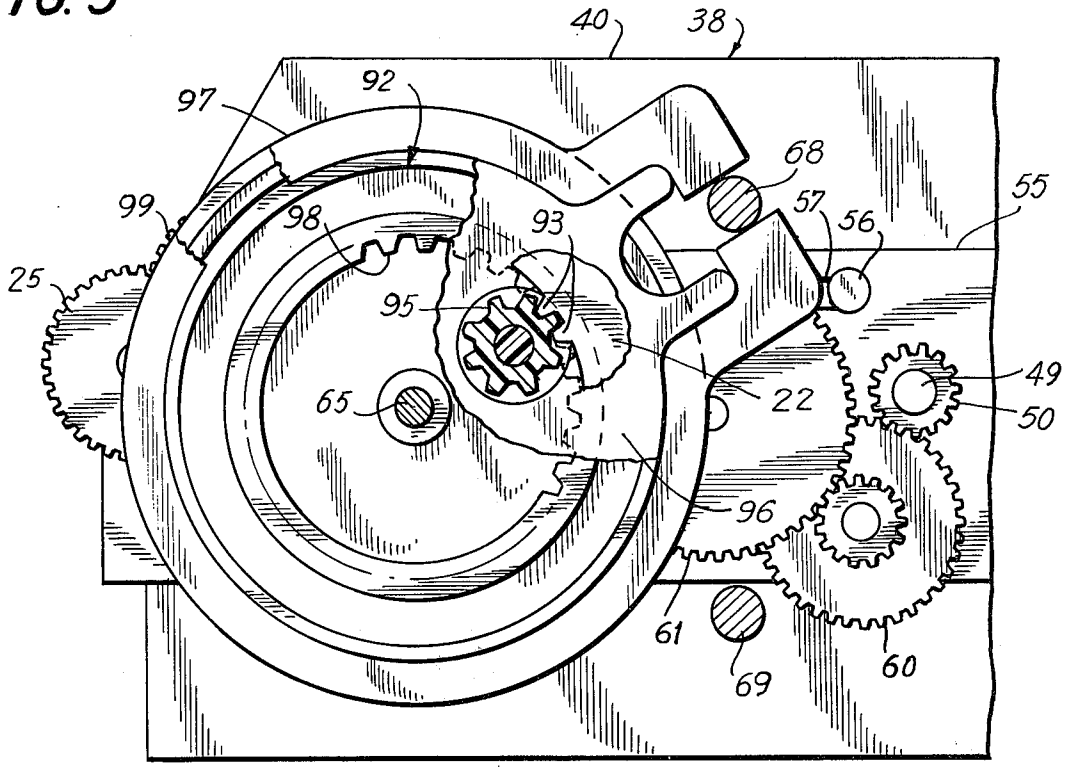

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FIG. 6

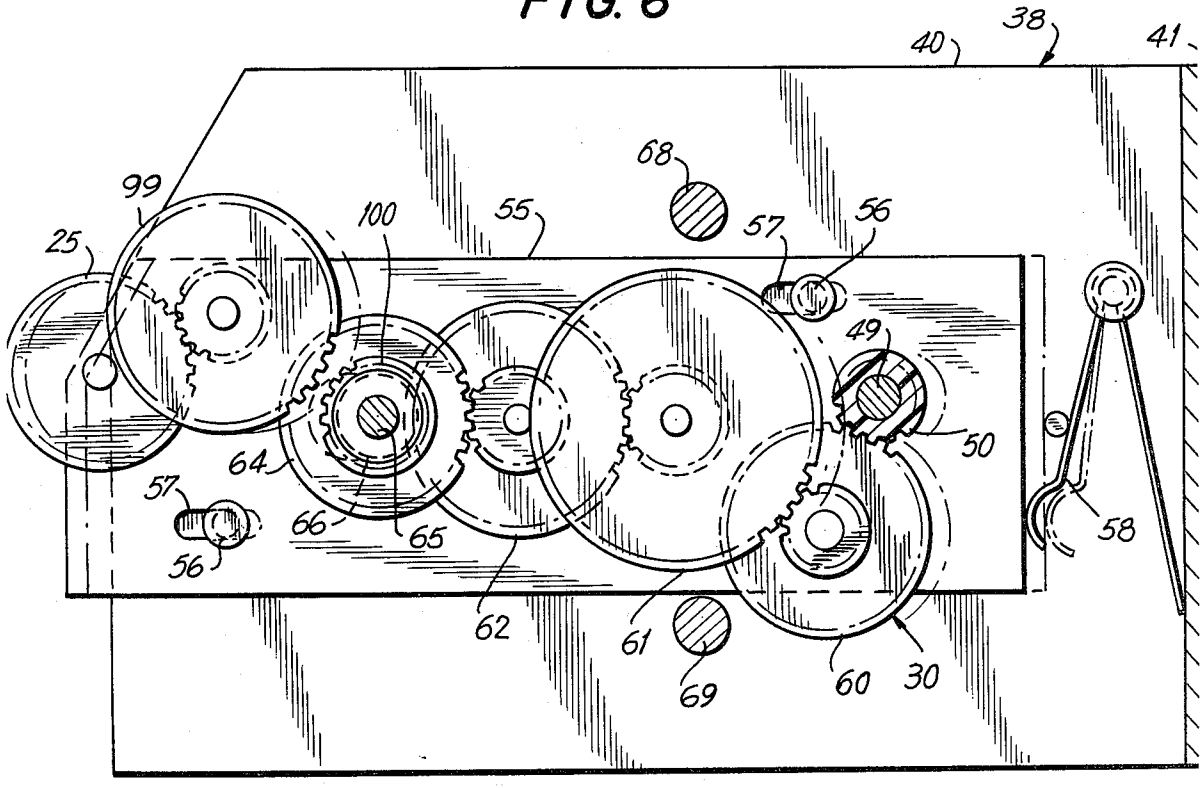

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FIG. 7

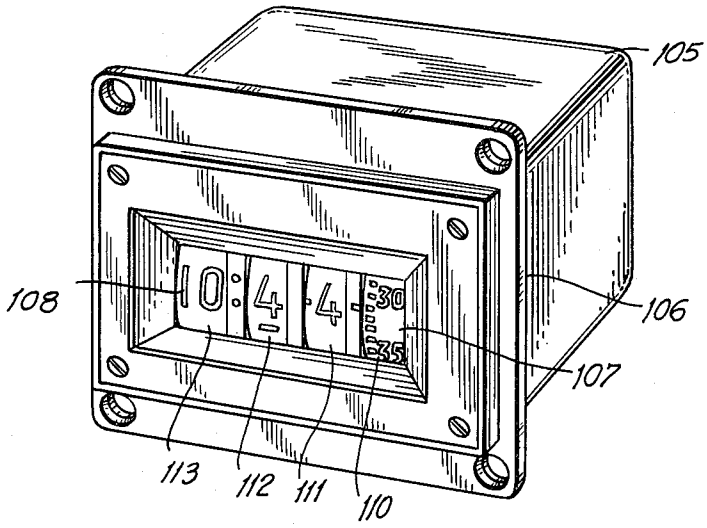
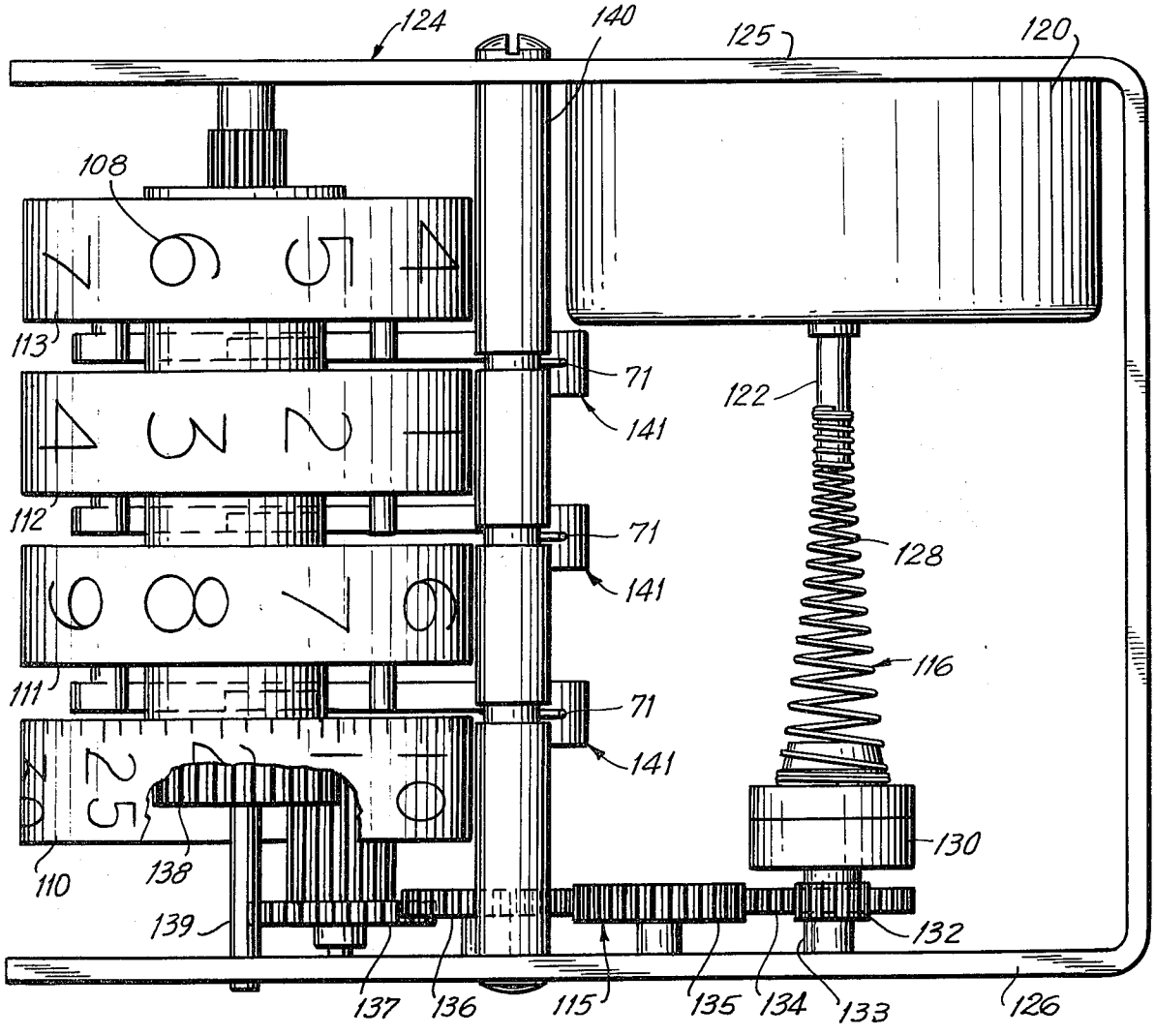

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FIG. 8


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DIGITAL CLOCK OR OTHER COUNTING DEVICE WITH RESILIENT COUPLING MEANS IN THE DRIVE TRAIN

BACKGROUND OF THE INVENTION

This invention relates to clocks and other counting devices, and more particularly to such devices which are provided with a resilient coupling between the drive motor of the device and the individual counting elements.

The present invention, while of general application, is particularly well suited for use with transfer counters of the type having a digital display indicating the correct time or other counting information. Representative counters of this type are disclosed in Arthur W. Haydon U.S. Pat. Nos. 3,069,083 granted Dec. 18, **1962** and 3,752,965 granted Aug. 14, 1973 and in G. O Hoffmann U.S. Pat. No. 3,223,322 granted Dec. 14, **1965.** To minimize power requirements and for other reasons, the counters preferably employ resiliently biased planetary gear mechanisms to transfer motion from one counting element to another, and for certain applications the counters advantageously are driven by stepper motors such as those disclosed in Arthur W. Haydon U.S. Pat. Nos. 3,495,107 granted Feb. 10, **1970** and 3,564,314 granted Feb. 16, 1971. The output shaft of the stepper motor is affixed to the input pinion for the gear train of the counter to apply discrete increments of energy through the gear train to the lowest order counting element, thereby advancing the counter one step for each revolution of the shaft.

Heretofore, digital clocks and other counting devices have exhibited certain disadvantages. For example, many such devices produced excessive noise or rattle, and for automobile clocks and other devices in which silent operation was desired the noise factor became a serious problem. In addition, and this has been of special moment for devices which use a stepper motor as the drive means, the devices occasionally exhibited unnecessary wear because of the repeated starting and stopping of the individual gears in the gear train. Furthermore, in prior counters having only a comparatively small number of counting elements, the advantages of the resiliently biased transfer mechanisms of the counters were not utilized to their fullest extent, and the attendant cost of such mechanisms resulted in counters which in many instances were too expensive for nonprecision applications.

SUMMARY

One general object of this invention, therefore, is to provide a new and improved clock or other counting device.

More specifically, it is an object of this invention to provide such a counting device which exhibits reduced noise and rattle during its operation.

Another object of the invention is to provide a counting device of the character indicated having more gradual movement of the various component parts in response to comparatively abrupt increments of energy applied to the input of the device.

Still another object of this invention is to provide a transfer counter utilizing simple mechanical and electrical components which is economical to manufacture and thoroughly reliable in operation.

In one illustrative embodiment of this invention, there is provided a transfer counter such as a clock

which comprises a plurality of indicia bearing register drums or other counting elements including a lower order element and a higher order element. A transfer mechanism interconnects the lower order element with the higher order element for operating the higher order element in response to operation of the lower order element and in prdetermined relationship therewith. The lower order element is driven by a suitable gear train or other speed reducing means which is mechanically connected to the output shaft of a stepper motor. The stepper motor applies energy to the gear train in discrete increments to operate the individual counting elements in accordance with the correct time or other information being counted.

In accordance with one feature of the invention, a resilient coupling is disposed between the drive motor and the speed reducing means to permit limited relative movement therebetween. The coupling advantageously exhibits a low "Q" and enables a very smooth and noiseless transfer of energy from the drive motor through the speed reducing means to the individual counting elements over a wide voltage range.

In accordance with another feature of the invention, in certain particularly important embodiments, the resilient coupling includes a novel damping member which operates both through inertia and frictional resistance to provide additional damping for the input of the speed reducing means. With this arrangement, the deleterious effects of noise, wear, etc. are reduced to a minimum.

In accordance with a further feature of some embodiments of the invention, driving motion is transferred to a lower order counting element through a resiliently biased transfer mechanism, while driving motion is transferred to at least one of the higher order counting elements by means of a Geneva or transfer pinion drive. The resilient bias on the transfer mechanism for the lower order element preferably provides sufficient force to operate two, three or even four higher order elements even though the higher order elements are driven by means of transfer pinions.

The present invention, as well as further objects and features thereof, will be understood more clearly and fully from the following description of certain preferred embodiments, when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a drum-type transfer counter in accordance with one illustrative embodiment of the invention.

FIG. **2** is an enlarged plan view of the counter of FIG. **1** with the cover removed.

FIG. **3** is a sectional view taken along the line **3—3** in FIG. **2.**

FIG. **4** is an enlarged fragmentary perspective view of portions of the drive mechanism for the counter.

FIG. **5** is a fragmentary sectional view taken along the line **5—5** in FIG. **2.**

FIG. **6** is a sectional view taken along the line **6—6** in FIG. **2.**

FIG. **7** is a perspective view of a drum-type transfer counter in accordance with another illustrative embodiment of the invention.

FIG. **8** is an enlarged plan view similar to FIG. **2** but illustrating the transfer counter shown in FIG. **7.**

DESCRIPTION OF CERTAIN PREFERRED EMBODIMENTS

The perspective view of FIG. 1 illustrates a transfer counter in the form of a 12 hour digital clock having a cover 15 and a face plate assembly 16. The clock is arranged for mounting in a suitable recess in an automobile dashboard (not shown) or other supporting structure. The assembly 16 includes a transparent insert 17 through which is visible suitable time indicating indicia 18 on a series of counting elements in the form of register drums. These drums comprise a second drum 20, a minutes drum 21, a tens of minutes drum 22 and an hour drum 23 which are arranged in progressively increasing order in coaxial relationship with each other.

The seconds drum 20 rotates in discrete increments or steps at a speed of one revolution per minute. The drum 20 is connected by unique planetary gearing to the minutes drum 21, and the particular gear ratios are such that, as the drum 20 rotates from its 0 seconds position to its 59 seconds position, the next higher order drum 21 remains stationary. As the drum 20 is rotated from its 59 seconds position to its 0 seconds position, however, the planetary gearing drives the drum 21 through a 36° angle to carry it from 0 to 1.

The minutes drum 21 is connected through a Geneva drive mechanism to the tens of minutes drum 22. As the drum 22 rotates from its 0 position to its 9 position, the drum 22 is held stationary, but during the rotation of the drum 21 from its 9 position to its 0 position the drum 22 turns through one-twelfth of a revolution to carry it from 0 to 1. In the illustrated embodiment the drum 22 is provided with two sets of digits, each numbered 0 through 5, and is arranged to rotate at a rate of one-half a revolution per hour.

In similar fashion, the tens of minutes drum 22 is connected through a Geneva drive mechanism to the hour drum 23, such that the hour drum 23 remains stationary during the rotation of the drum 22 between its 0 position and its 5 position, but as the drum 22 moves from its 5 position to the next 0 position the drum 23 is advanced one step or one-twelfth of a revolution for a 12 hour clock. A thumb wheel 25 protrudes through the face plate assembly 16 to enable the manual setting of the clock to the correct time.

As best illustrated in FIG. 2, the seconds drum 20 is connected through a speed reducing gear train 30 and a resilient coupling mechanism 31 to a two wire stepper motor 32. The motor 32 illustratively is of the type disclosed in Haydon U.S. Pat. No. 3,564,314 referred to above and includes a capsule assembly 33 containing the rotor and stator poles of the motor and a field coil 34 in spaced relationship with the capsule. The field coil 34 is supplied with equally spaced current pulses from the automobile battery (not shown) and a suitable oscillator circuit of conventional construction.

The various component parts of the clock are carried by a U-shaped mounting bracket 38. This bracket is provided with a pair of spaced legs 39 and 40 and a base portion 41. The motor capsule 33 is suitably affixed to the leg 39, while the filed coil 34 is affixed to the portion 41.

The motor 32 includes an output shaft 44 which is parallel to the axis of rotation of the counter drums 20, 21, 22 and 23. The shaft 44 is secured to the smaller end of a spiral or helical coil spring 45 which forms a part of the resilient coupling mechanism 31. From the shaft 44 the spring extends toward the mounting bracket leg 40 and gradually increases in diameter with its larger end connected to the hub portion 47 of a fly wheel 48.

The fly wheel 48 is rotatably carried on a stub shaft 49. Surrounding the shaft 49 is a pinion 50 and a sleeve 51 which serves as a thrust bearing for the wheel 48. The pinion 50 is affixed to the wheel 48, and the axial force of the spring 45 urges the wheel and pinion assembly against the bearing 51 to provide a degree of frictional resistance to the rotary movement of the wheel.

The stub shaft 49 is carried adjacent one end of a slidable plate 55. The plate 55 bears against the mounting bracket leg 40 and is movable toward and away from the rotational axis of the counter drums 20, 21, 22 and 23 in a manner that will become more fully apparent hereinafter. As best shown in FIG. 6, the plate 55 is supported by posts 56 which protrude through oblong apertures 57 in the plate to permit the plate to slide a predetermined distance along the leg 40. The plate is biased toward the axis of the counter drums by a leaf spring 58.

The slidable plate 55 carries the various components of the gear train 30. These components include three successive gear and pinion assemblies 60, 61 and 62 which provide the necessary speed reduction between the motor shaft 44 and the seconds drum 20. In the normal position of the plate 55 (the position illustrated in full lines in FIG. 6), the gear portion of the assembly 60 is in meshing engagement with the pinion 50 on the fly wheel 48, and the train proceeds through the pinion portion of the assembly 60 and the assemblies 61 and 62 to a drive gear 64 in coaxial relationship with the register drums 20, 21, 22 and 23. The gear 64 is affixed to a counter shaft 65 journaled from rotation between the legs 39 and 40 of the mounting bracket 38. This shaft extends through an enlarged opening 66 in the plate 55 to permit the plate to move relative to the shaft.

The counter shaft 65 serves as a support for the various register drums 20, 21, 22 and 23. Each of these drums is of molded plastic construction and includes a flange about its outer periphery which carries the indicia 18 and is spaced from the axis of the shaft 65 by a generally discshaped web section. The web sections of the various drums are located substantially midway between the edges of the corresponding flanges to form recesses in both faces of the drums. In the interests of compactness, these recesses accommodate substantial portions of the various operating components of the counter. The drums are arranged in progressively increasing order on the shaft 65 from the lowest order drum 20 to the highest order drum 23. The drum 20 is connected to the shaft 65 adjacent the mounting bracket flange 38 such that the drum rotates with the shaft.

As best shown in FIG. 3, two parallel rods 68 and 69 are disposed in spaced relationship with the assembly of register drums. The rods 68 and 69 extend in directions parallel to that of the counter shaft 65 between the legs 39 and 40 of the mounting bracket 38. The rod 69 pivotally supports a resiliently biased transfer mechanism 70 which is interposed between the seconds drum 20 and the next higher order drum 21 to transfer motion between the two drums. The transfer mechanism 70 is provided with a biasing spring 71 which

urges the mechanism in a counterclockwise direction, as viewed in FIG. 3, about the rod 69.

The side of the lowest order drum 20 which faces the minutes drum 21 includes a single lobe compensating cam 74 and a drive pinion 75. The facing side of the minutes drum 21, that is, the side adjacent the drum 20, is provided with a driven gear 76. These components are disposed wholly within the corresponding drum flanges and are integrally molded with the webs of the drums.

Interposed between the drums 20 and 21 is a generally cylindrical guide member 77 of a cage-type configuration. As more fully described in Haydon U.S. Pat. No. 3,752,965 referred to above, the guide member 77 is rotatable relative to the drums and serves to maintain the free end of the transfer mechanism 70 at a fixed radius with respect to the counter shaft 65.

The cage-type guide member 77 supports a planetary gear assembly 80 of one-piece plastic construction. This assembly comprises a large diameter gear 81 and a small diameter gear 82 which are in respective meshing engagement with the drive pinion 75 on the lowest order drum 20 and the driven gear 76 on the adjacent drum 21. An axle 83 is integrally molded with the planetary gears 81 and 82. The assembly 80 is freely rotatable relative to the guide member 77, and the guide member maintains the axle 83 at a fixed orbital distance from the rotational axis of the drums such that the gears 81 and 82 are held in meshing engagement with the corresponding pinion 75 and the gear 76 at all times.

The planetary gear assembly 80 orbits relative to the counter shaft 65 under the control of the compensating cam 74. The transfer mechanism 70 comprises an arm which extends in a direction transverse to the shaft 65 and includes a straight, rigid portion 85 pivotally carried at one end by the rod 69. The remaining portion 86 of the arm is comparatively flexible and extends along an arc substantially concentric with the shaft 65. The free end of the portion 86 is provided with an integrally formed pin 87 which is slidably disposed in a mating slot in the guide member 77.

A follower 88 is integrally molded with the transfer mechanism 70 at the point at which the arm portions 85 and 86 meet. The follower 88 comprises a small protrusion which rests on the compensating cam 74 and is resiliently urged against the cam by the biasing spring 71.

As more fully explained in the aforementioned Haydon patent 3,752,965, during the rotation of the seconds drum 20 in the drection of increasing count, its pinion 75 acts on the planetary gears 81 and 82 in a direction which tends to produce similar rotation of the adjacent higher order drum 21. However, as the drum 20 rotates from its 0 seconds position to its 59 seconds position, the compensating cam 74 urges the follower 88 away from the drum shaft 65 to tthereby pivot the transfer arm portion 85 and the gears 81 and 82 about the rod 69. The cam 74 is of single lobe construction and is contoured such that this later movement of the gears 81 and 82 exactly compensates for the tendency of the gears to drive the drum 21, so that the drum 21 remains stationary.

Upon the movement of the lowest order drum 20 between its 59 seconds position and its 0 seconds position, the follower 88 drops off the lobe on the cam 74 under the action of the stored tension in the biasing spring 71. The drum 21 thereupon rotates rapidly from its 0 position to its 1 position as the planetary gears 81 and 82 move around the rotational axis of the drums. With this arrangement, at the time motion is transferred to the drum 21, and hence to the succeeding drums 22 and 23, the energy needed to rotate the drums is derived from the spring 71, rather than from the input to the lowest order drum 20. As a result, even for counting devices having a large plurality of drums which transfer simultaneously, the imposition of substantial impact forces on the main input drive is eliminated.

Motion is transferred between the minutes drum 21 and the tens of minutes drum 22 and between the drum 22 and the hour drum 23 by means of conventional Geneva drive mechanisms 92. As best shown in FIG. 5, each of the mechanisms 92 includes a pair of internal transfer teeth 93 which are integrally molded on the side of the lower order drum 22, for example, which faces the adjacent higher order drum 23. As the drum 22 rotates, the teeth 93 are in position to engage a starwheel type transfer pinion 95. This pinion is rotatable about a stationary axis and is supported by a disc-shaped partition plate 96. The plate 96 is carried by the counter shaft 65 intermediate the lower and higher order drums. A ring-shaped separator 97 surrounds the plate 96 and serves as a spacer between the adjacent drums.

The drums 21, 22 and 23 are freely rotatable about the counter shaft 65. An integrally molded internal gear 98 is provided on the side of each of the drums 22 and 23 which faces the adjacent lower order drum. This gear meshes with the transfer pinion 95 such that, as the pinion 95 moves in response to its engagement with the teeth 93 on the lower order drum, it drives the gear and hence the higher order drum through one position. With respect to the tens of minutes drum 22, for example, the corresponding transfer pinion 95 rotates the drum 22 through an angle of thirty degrees in response to each revolution of the minutes drum 21. There are two sets of the teeth 93 on the tens of minutes drum 22 in diametrically opposed relationship with each other, and the hour drum 23 is rotated by its transfer pinion 95 through an angle of 30° in response to each one-half revolution of the drum 22. The particular angles through which the higher order drums rotate are of course illustrative and will depend on the intended use for the counter.

The thumb wheel 25 (FIG. 6) is carried adjacent the outer end of the slidable plate 55 such that the wheel protrudes through a suitable opening in the face plate assembly 16. The wheel 25 meshes with a gear and pinion assembly 99 on the plate 55, and this assembly is arranged for movement into meshing engagement with a pinion 100 affixed to the counter shaft 65. In the illustrated embodiment the pinion 100 is integrally molded with the drive gear 64.

In the normal position of the slidable plate 55, that is, the position shown in full lines in FIG. 6, the biasing spring 58 maintains the plate in a position such that the gear and pinion assembly 99 is spaced from the pinion 100. To reset the clock, the thumb wheel 25 is depressed to move the plate 55 against the resistance of the spring 58 and thereby bring the gear and pinion assembly 99 into meshing engagement with the pinion 100. During this movement, the fly wheel pinion 50 and the gear and pinion assemblies 60, 61 and 62 in the

gear train **30** are carried as a unit by the plate **55** toward the spring **58** to disengage the gear train between the assembly **62** and the drive gear **64.** This translatory movement of the gear train is readily accomplished by reason of the resilient coupling **31** between the train and the motor output shaft **44.** The thumb wheel **25** is then rotated to similarly rotate the gear and pinion assembly **99,** the pinion **100** and the counter shaft **65** to thereby move the seconds drum **20** to the desired position.

Upon application of each successive clock pulse to the field coil **34** (FIG. 2), the rotor of the motor **32** turns the output shaft **44** through a single complete revolution. Because of the resilient coupling mechanism **31,** the gear train **30** remains stationary during the initial portion of the shaft's rotation. As the tension in the spiral spring **45** increases, the fly wheel **48** begins to accelerate the gear train **30,** and the acceleration continues during the remaining portion of the operation of the shaft **44.** After the shaft **44** has come to rest, the spring **45** and the fly wheel **48** continue to drive the gear train **30** to operate the counter drums **20, 21, 22** and **23.** The spring **45** exhibits a low Q, with a comparatively small mass, to provide a very smooth and noiseless transfer of energy from the shaft **44** through the gear train **30** to the counter shaft **65** and the lowest order drum **20.**

The fly wheel **48** assists in the motion damping action of the spiral spring **45.** In addition, the rotary movement of the wheel **48** is frictionally resisted by the thrust bearing **51.** Although this frictional resistance provides some loss of energy, the inertia of the coupling is increased, and the deleterious effects of backlash are reduced to a minimum.

The arrangement is such that the kinetic energy provided by the drive motor **32** is converted into potential energy as a result of the resilient coupling mechanism **31.** The motor shaft **44** and the attached small end of the spiral spring **45** rotate through approximately one-half of a revolution before the large end of the spring, the fly wheel **48,** the gear train **30** and the counter drums **20, 21, 22** and **23** begin their movement. The potential energy within the spring thereupon begins to accelerate these components during the remaining portion of the shaft's rotation, and after the shaft has come to rest the fly wheel, the gear train and the counter drums continue their movement under the control of the resilient coupling mechanism.

The output shaft **44** of the motor **32** moves in abrupt increments or steps at a predetermined frequency. The resilient coupling mechanism **31,** on the other hand, drives the gear train **30** and the counter drums **20, 21,** 22 and **23** at the same frequency but in successive increments which each have a rate of speed substantially less than the corresponding increment of the output shaft. For each increment the output shaft rotates quickly through a given angle, while the counter drums or other load is driven slowly and thus quietly through either the same angle or a fraction thereof as determined by the intervening gear reduction.

The rotation of the lowest order drum **20** between its 0 position and its 59 position serves to store energy in the resiliently biased transfer mechanism **70.** The stored energy is sufficient to operate not only the minutes drum **21** but also the tens of minutes drum **22** and the hour drum **23** through the connecting Geneva drive mechanism **92.** Accordingly, as the drum **20** moves between its 59 position and its 0 position, the biasing spring **71** on the mechanism **70** provides the necessary force to operate the higher order drums, and there is no increase in the load on the input to the counter.

FIGS. **7** and **8** are illustrative of a transfer counter in accordance with another preferred embodiment of the invention. As in the previously described embodiment, the counter is in the form of a 12 hour digital clock which is particularly well suited for use in an automobile or other vehicle. The counter includes a cover **105** and a mounting plate **106** which is arranged for connection to an automobile dashboard, for example. The plate **106** is provided with a transparent insert **107.**

Suitable timing indicia **108** is visible through the transparent insert **107** and is arranged on the peripheral flanges of a series of register drums or other counting elements of progressively increasing order. These elements comprise a seconds drum **110,** a minutes drum **111,** a tens of minutes drum **112** and an hour drum **113.** The drums **110, 111, 112** and **113** are arranged for rotation about a common axis in a manner which is somewhat similar to that described heretofore with the exception that resiliently biased transfer mechanisms are utilized between each pair of adjacent drums to provide driving power to the higher order drums.

The lowest order drum **110** is connected through a speed reducing gear train **115** and a resilient coupling mechanism **116** to a two-wire stepper motor **120.** The stepper motor **120** illustratively is of the type disclosed in Haydon U.S. Pat. No. 3,495,107 referred to above and includes an output shaft **122** which rotates in discrete increments or steps in response to each current pulse applied to the motor.

The various component parts of the counter are supported on a U-shaped mounting bracket **124** having opposed legs **125** and **126.** The drive motor **120** is suitably affixed to the leg **125,** and the motor shaft **122** is secured to the smaller end of a spiral spring **128** which forms a part of the resilient coupling mechanism **116.** The large end of the spring **128** is attached to a fly wheel **130** which is rotatably mounted on the leg **126.** A pinion **132** is carried by the fly wheel **130** for rotation therewith, and the fly wheel and pinion assembly bears against a thrust bearing **133.**

The speed reducing gear train **115** also is supported on the leg **126** of the mounting bracket **124.** This gear train includes successive gears **134, 135** and **136** and a gear and pinion assembly **137.** The pinion portion of the assembly **137** meshes with a drive gear **138** which is integrally molded on the web of the seconds drum **110** to rotate the drum at a speed of one revolution per minute.

The seconds drum **110,** together with the remaining counter drums **111, 112** and **113,** are mounted for rotation about a stationary shaft **139** extending between legs **125** and **126** of the mounting bracket **124.** A support rod **140** also is carried between the legs **125** and **126** adjacent the peripheries of the drums. The rod **140** pivotally supports three planetary gear transfer mechanisms **141** which are respectively located between the drums **110** and **111,** the drums **111** and **112,** and the drums **112** and **113,** and serve to rotate the adjacent higher order drums only during a selected portion of the rotation of the lower order drums. Each of the mechanisms **141** is similar to the transfer mechanism **70** (FIG. 3) described heretofore and includes the bias-

ing spring **71**, the compensating cam **74**, the cage-type guide member **78**, the planetary gear assembly **80** and the follower **88**. To provide the desired movement of the hour drum **113** in response to each one-half revolution of the tens of minutes drum **112**, the compensating cam on this latter drum is of two lobe configuration with the lobes in diametrically opposed relationship.

The stepper motor **120** drives the motor shaft **122** in successive increments or steps. Because of the resilient coupling mechanism **116**, the fly wheel **130** and the speed reducing gear train **115** remain stationary during the initial portion of the operation of the motor shaft and then accelerate during the remaining portion of the shaft's operation. Upon the termination of each successive step of the motor, the fly wheel and gear train continue their movement with the result that a very smooth and uniform transfer of energy takes place to the seconds drum **110**. The coupling mechanism **116**, together with the action of the fly wheel **130** and the frictional resistance provided by the thrust bearing **133**, is effective to convert the kinetic energy from the motor shaft **122** into potential energy which is stored in the spring **128**. The potential energy of the spring in turn is used to drive the gear train **115** and the counter drums in the manner described heretofore.

In each of the illustrated embodiments of the invention, the counter and the drive motor and electronic circuitry therefor are enclosed in a sealed housing which comprises the cover **15** (FIG. 1) and the face plate assembly **16**, for example. The housing not only shields the unit from sand, dust, etc., but it also acts as a sound deadener and prevents tampering.

In several advantageous embodiments the thumb wheel **25** or other resetting device is connected through a suitable ratchet mechanism (not shown) to a tuning capacitor in the electronic circuit. The ratchet provides a small adjustment in the tuning of the capacitor, either to speed the clock up or slow it down depending upon the desired time correction. The arrangement is such that the clock speed is automatically adjusted each time the user makes a correction.

Although the invention has been described and illustrated with particular reference to a transfer counter in the form of a digital clock, it will be apparent that the novel construction and arrangement of the various parts also are applicable to other types of motion transfer mechanisms. For example, the invention may be readily designed for use in decade or other numerical counters, elapsed time indicators, thumb wheel switches, etc., and it also may be employed for non-counting applications in which it is desired to resiliently couple a drive motor to a load.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

What is claimed is:

1. A transfer counter such as a clock, which comprises, in combination:

a plurality of transfer elements including a lower order element and a higher order element;

resiliently biased transfer means interconnecting the lower order element with the higher order element for operating the higher order element in response to operation of the lower order element and in predetermined relationship therewith;

speed reducing means in driving relationship with the lower order element;

means including a stepper motor having a rotary output shaft rotatable in discrete increments of motion for operating the speed reducing means; and

a resilient coupling between the operating means and the speed reducing means for permitting relative rotational movement therebetween, the resilient coupling including a coil spring connected at one end to the motor output shaft, a fly wheel connected to the opposite end of the spring and in driving relationship with the speed reducing means, and means for frictionally resisting axial movement of the fly wheel, the speed reducing means remaining stationary during the initial portion of the operation of said operating means, then accelerating during a succeeding portion of said operation, and thereafter continuing its movement upon the termination of each said increment under the control of said resilient coupling.

2. A transfer counter as defined in claim **1**, in which the means for frictionally resisting axial movement of the fly wheel comprises a thrust bearing for supporting said wheel.

3. A transfer counter such as a clock, which comprises, in combination:

a plurality of register drums rotatably arranged in progressively increasing order with each other;

first transfer means interconnecting the lowest order drum with the adjacent higher order drum, the first transfer means including a resiliently biased transfer mechanism for rotating said adjacent drum only during a selected portion of the rotation of the lowest order drum;

second transfer means interconnecting said adjacent higher order drum with the next higher order drum, the second transfer means including means for rotating the next drum only during a selected portion of the rotation of said adjacent drum;

speed reducing means in driving relationship with the lowest order drum;

means including a stepper motor having a rotary output shaft for operating the speed reducing means in discrete increments of motion; and

a resilient coupling between the motor output shaft and the speed reducing means for permitting relative rotational movement therebetween, in which the resilient coupling comprises:

a coil spring connected at one end to the motor output shaft,

a fly wheel connected to the opposite end of the spring and in driving relationship with the speed reducing means, and

means for frictionally resisting axial movement of the fly wheel.

4. A transfer counter such as a clock, which comprises, in combination:

a plurality of register drums rotatably arranged in progressively increasing order with each other;

first transfer means interconnecting the lowest order drum with the adjacent higher order drum, the first transfer means including a resiliently biased transfer mechanism for rotating said adjacent drum only during a selected portion of the rotation of the lowest order drum, the lowest order drum moving the

transfer mechanism against its resilient bias during the remaining portion of the lowest order drum's rotation;

second transfer means interconnecting said adjacent higher order drum with the next higher order drum, the second transfer means including a Geneva transfer mechanism for rotating the next drum only during a selected portion of the rotation of said adjacent drum;

speed reducing means in driving relationship with the lowest order drum;

means including a drive motor having a rotary output shaft for operating the speed reducing means; and

a coupling member between the motor output shaft and the speed reducing means for transmitting rotational movement thereto.

5. A transfer counter such as a clock, which comprises, in combination:

a plurality of register drums rotatably arranged in progressively increasing order with each other;

first transfer means interconnecting the lowest order drum with the adjacent higher order drum, the first transfer means including a compensating cam secured to the side of the lowest order drum facing said adjacent drum, first drive means secured to the side of the adjacent drum facing said lowest order drum, and a resiliently biased transfer mechanism controlled by the compensating cam for rotating said first drive means only during selected portion of the rotation of the lowest order drum;

second transfer means interconnecting said adjacent higher order drum with the next higher order drum, the second transfer means including second drive means secured to the side of said next drum facing said adjacent drum and a Geneva transfer mechanism only during a selected portion of the rotation of said adjacent drum;

speed reducing means including a gear train in driving relationship with the side of the lowest order drum opposite that facing said adjacent drum;

means including a stepper motor having a rotary output shaft for operating the gear train; and

a coupling member between the motor output shaft and the speed reducing means for transmitting rotational movement thereto.

6. A transfer counter as defined in claim **5,** in which the Geneva transfer mechanism comprises a star wheel.

7. A transfer counter such as a clock, which comprises, in combination:

a plurality of register drums rotatably arranged in progressively increasing order with each other;

first transfer means interconnecting the lowest order drum with the adjacent higher order drum, the first transfer means including a compensating cam secured to the side of the lowest order drum facing said adjacent drum, first drive means secured to the side of the adjacent drum facing said lowest order drum, and a resiliently biased transfer mechanism controlled by the compensating cam for rotating said first drive means only during a selected portion of the rotation of the lowest order drum;

second transfer means interconnecting said adjacent higher order drum with the next higher order drum, the second transfer means including second drive means secured to the side of said next drum facing said adjacent drum and a Geneva transfer mechanism for rotating the next drum only during a selected portion of the rotation of said adjacent drum;

speed reducing means including a gear train in driving relationship with the side of the lowest order drum opposite that facing said adjacent drum;

means including a stepper motor having a rotary output shaft rotatable in discrete increments of motion for operating the gear train; and

a resilient coupling between the motor output shaft and the speed reducing means for permitting relative rotational movement therebetween, the speed reducing means remaining stationary during the initial portion of the operation of said output shaft, then accelerating during a succeeding portion of said operation, and thereafter continuing its movement upon the termination of each said increment under the control of said resilient coupling.

8. A transfer counter such as a clock, which comprises, in combination:

a plurality of register drums rotatably arranged in progressively increasing order with each other;

first transfer means interconnecting the lowest order drum with the adjacent higher order drum, the first tranfer means including a compensating cam secured to the side of the lowest order drum facing said adjacent drum, first drive means secured to the side of the adjacent drum facing said lowest order drum, and a resiliently biased transfer mechanism controlled by the compensating cam for rotating said first drive means only during a selected portion of the rotation of the lowest order drum;

second transfer means interconnecting said adjacent higher order drum with the next higher order drum, the second transfer means including second drive means secured to the side of said next drum facing said adjacent drum and a Geneva transfer mechanism for rotating the next drum only during a selected portion of the rotation of said adjacent drum;

speed reducing means including a gear train in driving relationship with the side of the lowest order drum opposite that facing said adjacent drum;

means including a stepper motor having a rotary output shaft for operating the gear train; and

a resilient coupling between the motor output shaft and the speed reducing means for permitting relative rotational movement therebetween, the coupling comprising a spiral spring connected to the gear train and affixed at one end to the output shaft for permitting the speed reducing means to remain stationary during the initial portion of the operation of said stepper motor, then accelerating the speed reducing means during the remaining portion of said operation, and thereafter continuing the movement of the speed reducing means.

9. A transfer counter as defined in claim **8,** which further comprises:

a rotatable fly wheel for connecting the spiral spring to the gear train; and

thrust bearing means for frictionally resisting rotary movement of the fly wheel.

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