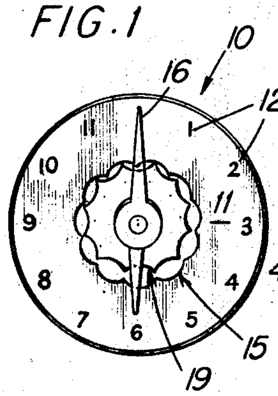
SPEED REDUCER MECHANISM ESPECIALLY AS EMBODIED IN CLOCKWORK

Filed July 12, 1967 2 Sheets-Sheet 1

FIG. 1



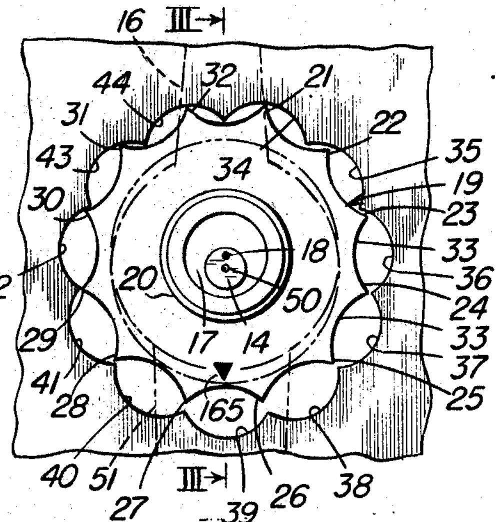
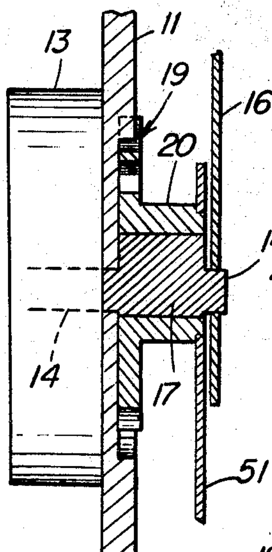


FIG. 2

FIG. 3



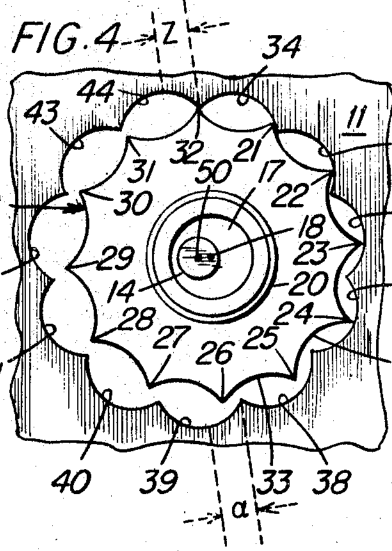
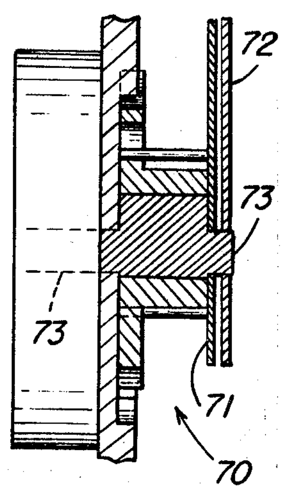


FIG. 8



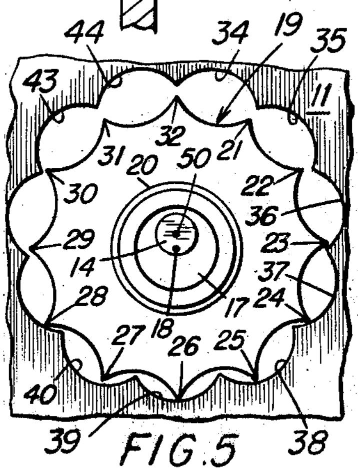


FIG. 5

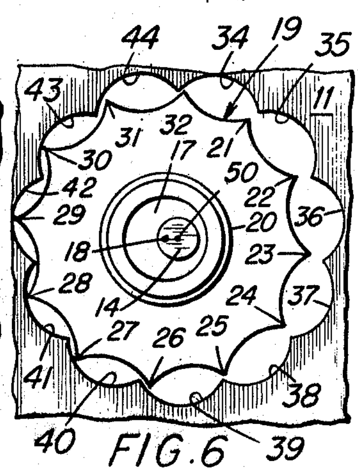


FIG. 6

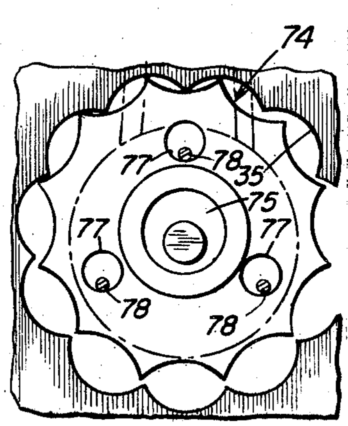
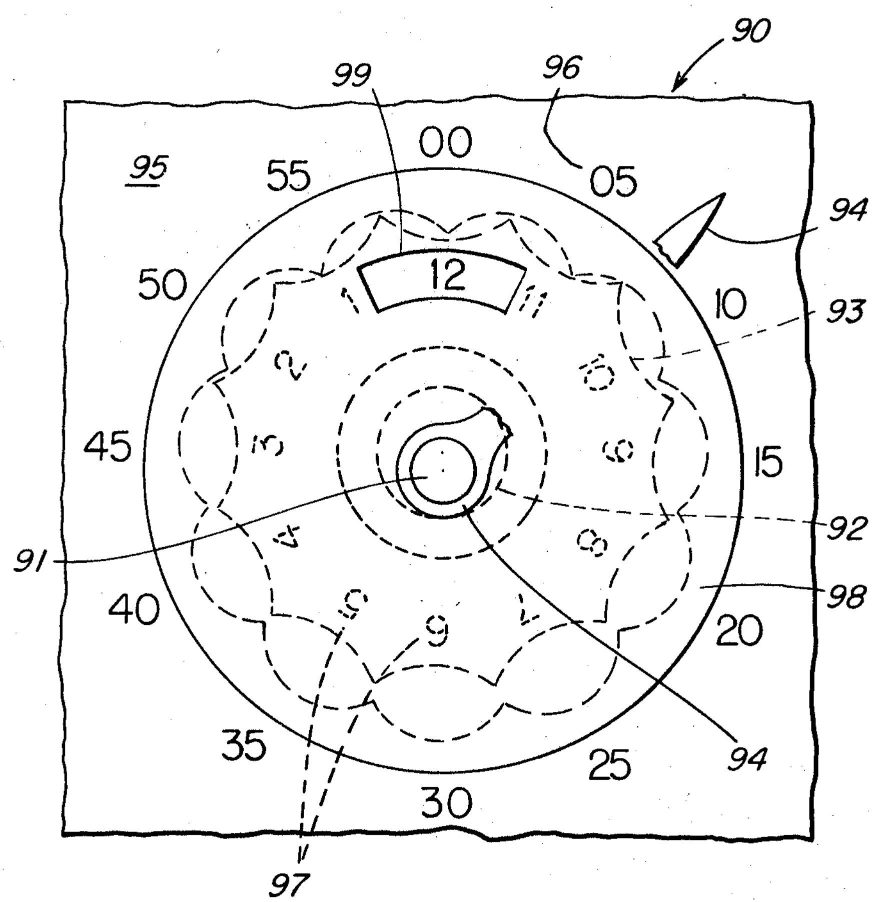


FIG. 7

FIG. 9


90
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94
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97

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SPEED REDUCER MECHANISM ESPECIALLY AS EMBODIED IN CLOCKWORK

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U.S. Cl. 58—7 10 Claims

ABSTRACT OF THE DISCLOSURE

A mechanism for a clockwork in which the minute hand is mounted on central shaft, adapted to be rotated at a constant speed of one revolution per hour. An eccentric is connected with the shaft and rotates in unison therewith about the axis of the shaft. A rotary star wheel is mounted on the eccentric for rotative movement independently of the movement of the eccentric and serves as the structure to which the clockwork hour hand is connected, the star wheel having a plurality of circularly spaced teeth extending around the periphery thereof. Encircling the star wheel is a fixed frame structure presenting a plurality of curvilinear camming surfaces arranged circularly of the axis of the central shaft. Rotation of the eccentric produces an orbiting bodily movement of the rotary star wheel about a common central area within which is located the axis of the central shaft. In the course of the orbital movement, the teeth of the star wheel each engage and disengage with a different one of successive camming surfaces on the fixed structure during correspondingly successive orbital revolutions, thereby producing a revolution of the star wheel about its own axis. The number of camming surfaces on the fixed frame totals eleven whereas the rotary star wheel is provided with twelve teeth, this being the mathematical arrangement required to enable the star wheel to make an advance of $\frac{1}{12}$ revolution about its own axis during each orbital revolution thereof accompanying a corresponding complete revolution of the eccentric, thereby advancing the clock hour hand from one to a succeeding hour hand designation on the clock dial face.

BACKGROUND OF THE INVENTION

The present invention relates to a mechanism with which a speed change can be effected between a first driving member and a second driven member rotatable unidirectionally about a common central area, the paths of rotation of the members traversing parallel planes. A specific embodiment of the mechanism is utilized for rotating the hour hand of a clockwork by converting output from the minute hand drive shaft to the lesser rotational speed at which the hour hand must move. The mechanism is characterized by requiring only one moving part in addition to the rotatable shaft on which the minute hand is mounted to produce the speed reduction manifested in the hour hand.

In the conventional clockwork mechanism, the minute and hour hands are usually mounted on separate co-axial members with drive from one of the members (the minute hand shaft) being provided to the member on which the hour hand is mounted through a gear train comprised of four gears designed to produce a speed reduction of 12 to 1 between the respective members. Four gears are necessary to provide unidirectional rotation of the hands and each of the gears in the train must have a different tooth count since no identical gear pairs exist which will provide the necessary speed reduction. Clock manufacturing is a competitive business so that the elimination of even one element from the clockwork can result in substantial cost savings in mass production manufacturing.

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One recourse for eliminating unnecessary clockwork elements can be the use of the clockwork of a two-gear clock mechanism of the type described in Ingenious Mechanisms for Designers and Inventors, ed. by F. D. Jones, New York, Industrial Press, 1954, vol. 1, p. 340–342. This device includes a first gear on which the hour hand is mounted and has twelve teeth which are arranged in a manner similar to those on a crown gear. A second gear having eleven teeth is located within the first gear and is mounted on an eccentric fixed to the minute hand drive shaft, the latter being concentric with a hub to which the first gear is fixed. As the minute hand shaft and eccentric rotate, the second gear moves in an orbit about the axis of the minute hand drive shaft but does not rotate about its own axis as a rod is connected to the second gear and the clock housing to prevent this form of movement. Each time the minute hand shaft and eccentric make one revolution, the second gear engages a selected space between succeeding teeth on the first gear causing the latter to move $\frac{1}{12}$ of a revolution. This device functions like a planetary gear set with tooth relative motion conventional to the operation of such gears in spite of the fact that as a feature thereof the second gear is prevented from rotating about its own axis and instead the first gear rotates. In other words, there occurs relative movement between the teeth on these gears in the same manner as that present between the teeth of any conventional counter-rotating gear set. The present invention on the other hand provides a totally different type of mechanism wherein the relative motion between the engaging elements thereof (which correspond with the two gear members of the Ingenious Mechanism device) is positive and opposite to that occurring between engaging gears.

An important improvement of the mechanism of the present invention over the Ingenious Mechanism device is that the latter requires three separate moving parts to function, i.e., first gear, second gear and rod connected to the second gear. The present invention on the other hand requires only a single moving part, viz., the rotary star wheel. This feature enables a considerable savings to be achieved in clock manufacture in that only one of the elements in the mechanism of the invention need be specially produced since conventional clock parts can be modified to serve as the other elements in the mechanism.

SUMMARY OF THE INVENTION

The speed changer mechanism of the present invention is intended to provide for the unidirectional rotation of first and second members at differential speeds about a common central area wherein is located the axis about which the first member rotates. A feature of the mechanism is that the speed conversion between the two members is achieved without recourse to conventional gearing. A particular embodiment involves the use of the mechanism in a clockwork. Thus an important object of the invention is to provide an improved clockwork mechanism requiring the use of a minimum of parts thereby substantially reducing mass production manufacturing costs of the mechanism as compared with known types of mechanisms. A further feature of the mechanism is that the structure thereof has larger, more open contours and less tooth-like elements than the conventional gears used in clockwork mechanism heretofore. A specific object of the invention is to reduce the number of moving parts in the minute-hour hand ratio mechanism of a clockwork to one moving part only. In accordance with the invention, an eccentric is connected with the minute hand shaft of a clock and rotates in unison therewith and about the same axis as the shaft. A rotary star wheel is mounted on the eccentric to rotate thereon independently of the movement of the eccentric and serves to carry the clock hour hand, the star wheel being provided with twelve teeth circularly spaced around the periphery thereof. A fixed frame structure encircles the star wheel and is provided with eleven curved or curvilinear cam surfaces circularly spaced around the axis about which the shaft rotates. As the minute hand shaft and hence the eccentric rotates, the rotary star wheel is caused to move with a bodily orbital revolution of the star wheel relative to the minute hand shaft axis with the teeth on the star wheel moving into and out of engagement with the camming surfaces on the fixed frame, the interaction between the star wheel teeth and fixed frame camming surfaces attending each engagement and disengagement being effective to impart a movement of rotation to the star wheel about its own axis thereby advancing the star wheel in the same direction as the eccentric rotates. When the mechanism its embodied in a clock twelve teeth are provided on the rotary star wheel and eleven camming surfaces against which they can engage are provided on the fixed frame and the rotation of the star wheel about its own axis is one-twelfth of that made by the eccentric. Thus the hour hand moves with substantially uniform movement between succeeding hour positions each time the minute hand completes one complete revolution around the clock dial face.

According to the invention, the dial of the clock itself may serve as the fixed structure in which the camming surfaces are formed in which event, the dial would be provided with a central aperture defined by the camming surfaces.

BRIEF DESCRIPTION OF THE DRAWINGS

A fuller understanding of the nature and objects of the invention will be had from the following detailed description taken in conjunction with the accompanying drawings in which is:

FIGURE 1 is a front view of a clock embodying the clockwork mechanism of the present invention.

FIGURE 2 is a front view on enlarged scale of the clockwork mechanism as viewed when the hands are removed from the clock shown in FIGURE 1.

FIGURE 3 is a sectional view as taken along the line III—III of FIGURE 2.

FIGURES 4, 5 and 6 are the same as FIGURE 2, except they show, respectively, the clockwork mechanism condition after the minute hand drive shaft has rotated in a clockwise direction one-quarter, one-half, and three-quarters of a revolution from the position shown in FIGURE 2.

FIGURE 7 is a view similar to FIGURE 2 but of an alternate embodiment of the clockwork mechanism wherein the hour hand instead of being fixed to the rotary star wheel hub is loosely supported on the minute hand drive shaft but drivingly coupled to the star wheel by means of pins.

FIGURE 8 is a sectional view similar to FIGURE 3 as related to the clockwork mechanism embodiment of FIGURE 7.

FIGURE 9 is a front view of a clock embodying the clockwork mechanism of the present invention wherein the rotary star wheel serves as the hour indicator in place of a conventional hour hand.

Throughout the description like reference numerals are used to denote like parts in the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The speed changer mechanism of the present invention will be described herein in representative embodiments which are adapted for use in a clockwork. However, it will be readily discernible by those skilled in the art from a reading of the present description that the invention has a more general applicability to devices involving the unidirectional movement of first and second members about a common central area at differential speeds, as for example, in mechanical counters. The reduction of unnecessary parts contributes to compactness of size and weight reduction in the devices with which the mechanism is used.

Referring now to FIGURES 1 to 3 of the drawings the clock **10** includes the customary dial comprised of a plate **11** the front surface of which is marked with indicia characters **12** denoting the usual clock hour designations. Located at the rear of the plate **11** is a clock movement **13** providing motive means for powering the clockwork, the clock movement being of known construction, as for example, a spring wound clock movement. The clock movement includes an output shaft **14** which extends centrally through central aperture **15** formed in plate **11** as best seen in FIGURE 2, the output shaft **14** being adapted to rotate as is customary in spring wound clocks at a speed of one revolution per hour. The minute hand **16** of the clock is fixed to output shaft **14** in known manner preferably being located at the frontmost end thereof.

The output shaft **14** includes an eccentric **17** which can either be formed integral with the shaft structure or be a separate member fixedly secured to the output shaft to rotate in unison therewith. As will be noted best in FIGURE 2, the eccentric has a cylindrical outer surface and will turn or rotate about the same axis **50** as the output shaft, with the center of the eccentric being radially offset therefrom at a location as at **18**. As part of the mechanism of the invention, there is provided a rotary star wheel **19**, the latter having a central hub portion **20** which encloses the eccentric **17** with a sufficient tolerance of fit to rotate about its own axis independently of the rotative movement of the eccentric. It will be understood that the axis of the rotary star wheel is coincident with the center **18** of the eccentric. The rotary star wheel **19** has a plurality of circularly spaced projections or teeth **21–32** extending around the periphery thereof and each constituting a cam follower, the teeth each being formed by a pair of intersecting curved edge surfaces **33** of the star wheel. The edge surfaces **33** generally follow the curve of a cycloid although curves comprised of arcs of a circle also can be used without representing a departure from the teaching of the present invention. The important requirement is that the curved edge surfaces **33** be symmetrical about the axis of the star wheel to provide that the teeth **21–32** formed by the intersection of the pairs of surfaces are equidistant from the axis of the star wheel.

The element of the mechanism which cooperates with the rotary star wheel for producing speed differential is the fixed frame structure constituted by plate **11** and more specifically, the structure defining aperture **15**. As may be best discerned by reference to FIGURE 2, the aperture **15** is comprised of a plurality of intersecting curved edge surfaces **34–44** formed in the plate and which similar to the edge surfaces **33** of the star wheel can be cycloidal-like curves of equal lengths arranged circularly of the axis of the minute hand shaft and equidistant therefrom. The curved edge surfaces **34–44** constitute camming surfaces along which the teeth **21–32** on the rotary star wheel **19** engage during the course of the movement of the latter in the manner to be described later on in the description. In forming the aperture **15** in the plate **11**, the same may be laid out as part of an initial design or existing clock dial plates may be modified accordingly.

With respect to the curved edge surfaces **33** on the rotary star wheel **19** and the edge surfaces **34–44** in plate **11**, the number and radius of curvature of the respective surfaces will be determined by a number of factors including the speed differential involved between the two members being rotated by the mechanism, the eccentricity of the star wheel and the other geometric dimensions of the mechanism. As embodied in a clockwork mechanism involving a speed reduction of 1 to $1/N$ between a first driving member and a second driven member, the second member (rotary star wheel) is provided with N-twelve teeth **21–32** and the aperture **15** in plate **11** is formed with N—1 or eleven camming surfaces **34–44**.

Turning now to consideration of the manner in which the mechanism operates to rotate the clock hands and with continuing reference to FIGURES 2, 4, 5 and 6, the mechanism will convert the one revolution per hour output of shaft **14** to one-twelfth of a revolution per hour of the rotary star wheel **19** about its own axis. It will be understood from the teaching of the invention that while the shaft **14** rotates about its own axis (point **50** in FIGURE 2), the axis of the rotary star wheel **19** is not coincident therewith so that the rotative movement of the clock minute hand **16** and hour hand **51** of this particular embodiment of clock are not in fact movements about a common axis as is the case with conventional clocks. Instead, the rotative movements of the clock hands will be about a common central area of circular section within which is located the axis of shaft **14**, the radius of the central circular area being the distance between the axis of shaft **14** and the center of the eccentric **17**. The axis about which the rotary star wheel rotates, i.e., its own axis, will constantly move in relation to the rotation of the eccentric, the movement being in a circular path defined by the circumference of the central area. For convenience of illustration, the position of the eccentric **17**, and rotary star wheel **19** have been shown in FIGURE 2 as those corresponding to the time six o'clock. As will appear, the star wheel and eccentric positions will be substantially the same as in FIGURE 2 whenever the minute hand **16** is at the hour position. Similarly, the eccentric and rotary star wheel will occupy the positions shown in FIGURES 4, 5 and 6 whenever the minute hand is in positions corresponding to a quarter past, one-half past, and three-quarters past the hour. As was earlier mentioned in the description, the revolution of the rotary star wheel **19** about its own axis is produced by the engagement of the rotary star wheel teeth with the camming surfaces on the fixed plate **11**, in a manner which produces bodily rotative motion in the star wheel and hence speed reduction independently of other fatctors such as loading on the start wheel. However, the exact pattern of and sequence of the tooth-camming surface engagements may vary depending on the condition of the loading of the rotary star wheel, that is, whether a torque is applied thereto and if so, whether it is applied in the direction of rotation of the rotary star wheel or in a direction opposite to said direction of rotation. If the torque is applied in the direction of rotation of the rotary star wheel **19** the teeth thereof will engage the camming surfaces at a location substantially 90° behind the maximum throw of the eccentric. The maximum throw of the eccentric occurs at a location on a radial line extending from the center of rotation of the eccentric (axis **50**) through and beyond the central axis of the eccentric (axis **18**). On the other hand, if the torque is applied in a direction opposite to rotation of the rotary star wheel, tooth engagement with the camming surfaces ccurs substantially 90° in advance of the maximum throw of the eccentric. As the clock hour hand **51** advances from the six o'clock to seven o'clock position, and assuming that the torque is applied in the direction of rotary star wheel rotation, the rotary star wheel teeth engagements occur according to the pattern shown in FIGURES 2, 4, 5 and 6. Thus as the shaft **14** (and the minute hand **16** and eccentric **17**) moves from the position shown in FIGURE 2 to that shown in FIGURE 4, making one-quarter of a clockwise revolution, the rotary star wheel **19** undergoes a compound movement. It makes one-quarter of a bodily orbital revolution about the axis of shaft **14** and it also moves in a partial revolution about its own axis **18**, the partial revolution accruing as an effect of the engagement of the teeth **30**, **31** and **32** of the rotary star wheel **10** with the camming surfaces **42**, **43** and **44**, respectively, on the fixed frame structure. Disengagement of these teeth from the camming surfaces will occur as the eccentric continues to rotate an additional quarter revolution between the positions of FIGURES 4 and 5 during the course of which the rotary star wheel makes a further bodily orbital revolution of one-quarter revolution about the axis of shaft **14**. In the course of the latter orbital revolution teeth **21**, **22** and **23** and **24** are brought into engagement with camming surfaces **34**, **35**, **36** and **37** causing further revolution of the rotary star wheel about its own axis. In moving from the FIGURE 5 to the FIGURE 6 position, the eccentric will move teeth **25**, **26** and **27** into engagement with camming surfaces **38**, **39** and **40** and in moving from the FIGURE 6 to the FIGURE 2 position of the eccentric, the eccentric in completing the full revolution thereof will cause engagement of teeth **27**, **28** and **29** with camming surfaces **40**, **41** and **42** to further revolve the rotary star wheel about its own axis, the star wheel having advanced 1/12 revolution about its own axis so that at seven o'clock tooth **32** will now be located within camming surface **34**. With torque acting in a direction opposed to rotation of the star wheel, the contact of the respective rotary star wheel teeth with the camming surfaces takes place along an initial segment of the camming surfaces, this segment being denoted α as related to camming surface **39** (FIGURE 4), it being understood that similar segments exist in each of the remaining camming surfaces. Conversely, the tooth-camming surface contact when the rotary star wheel is subjected to torque applied in the directtion of rotation occurs along a terminal segment of each camming surface as illustrated by way of example on FIGURE 4 as segment Z as applied to camming surface **44**. The net result of the eccentric making one complete revolution is to cause the rotary star wheel to bodily orbit one revolution about the axis of shaft **14**. Also since there are twelve teeth on the rotary star wheel but only eleven camming surfaces with which they can engage, the revolution of the rotary star wheel about its own axis is one-twelfth of that of the eccentric. It will be understood that the one-twelfth of a revolution rotation of the rotary star wheel about its own axis is a substantially continuous rotation produced as incremental rotational movements of the star wheel accompanying the disengagement of one star wheel tooth from a camming surface accompanied simultaneously by the engagement of another tooth with a correpondingly different camming surface. The rotation of the star wheel **19** about its own one-twelfth of a revolution for each revolution of the eccentric thus provides a generally smooth advance of the clock hour hand **51** between succeeding hour indicia **12** on the clock dial face.

The foregoing thus describes the mode of tooth engagement with the camming surfaces as occurs when torque is applied in the direction of rotary star wheel rotation. On the other hand, it will be understood that when a torque is applied to the rotary star wheel opposite to the direction of rotation, the tooth-camming surface engagements will occur at reciprocal locations (along initial portions of the camming surfaces) to those shown in FIGURES 2, 4, 5 and 6.

In the mechanism shown in FIGURE 3, the hour hand **51** of the clock is mounted fixedly to the hub **20** of the rotary star wheel so that the axis about which same rotates is constantly moving. The mechanism **70** shown in FIGURES 7 and 8 on the other hand allows for rotation of the hour hand **71** about a common axis with the minute hand **72**. In this embodiment, the minute hand **72** is fixed to the movement shaft **73** to rotate therewith. The hour **71** however is mounted loosely on the same shaft. The mechanism includes a rotary star wheel **74**, eccentric **75** and apertured plate **76** of the same construction and serving the same functions as previously described. The star wheel is however provided with a number of openings **77** arranged therein symmetrically about the central axis of the star wheel. The greater the number of openings **77**, the easier will be the operation of mechanism, the minimum number of openings **77**, with which the mechanism is effectively operated being three. The hour hand **71** is coupled with the star wheel by means of a corresponding number of pins **78** fixed to the hour hand and extending loosely into the openings **77**. As the rotary star wheel rotates about its own axis, the rotative motion thereof is transmitted to the hour hand **71** by means of the pins **78**. The openings **77** are of larger size than the pins **78** to allow relative movement of the latter during radial displacements of the star wheel relative to the axis of shaft **73**. The actual radius of the openings **77** are determined as the sum of the radius of eccentricity of eccentric **75** plus the radius of the pins **78**. It will be understood of course that while the clock hands **71**, **72** will rotate about a common axis (the axis of shaft **73**), the rotation of the rotary star wheel **74** will as with the embodiment of FIGURE 2 be about an axis that shifts along a circular path spaced around the axis of shaft **73**.

It is well known in the clock art to manufacture clocks with which the time is presented digitally. In the digitally presented time clock, the clock usually includes discs which are used in place of conventional hands, these discs in turn being provided with windows in which the current time digits appear. The mechanism of the present invention is especially adapted for use in the manufacture of this type of clock since it already includes a disc, i.e., the rotary star wheel. This eliminates the need for a separate numbered hour disc. This important advantage of the invention can be seen with reference to FIGURE 9 which shows a clock **90** that includes a minute hand shaft **91**, eccentric **92**, rotary star wheel **93**, minute hand **94** and dial face **95**, marked with minute indicia **96**. The rotary star wheel however is provided with hour indicia **97** on the front face thereof but with the arithmetical progression ascending in a counterclockwise direction. A cover member **98** is fixed to plate **95** and covers over the central portion of the face of the clock and is provided with a window opening **99**. The window opening **99**, it will be noted, is of sufficient size to span two hour indicia **97** enabling the viewer to ascertain readily the time reading particularly at the half-hour time. The time is read by correlating the hour indicia **97** locating in window **99** with the position of the minute hand **94**. Thus in FIGURE 9, the time depicted is 12:08. Each time the minute hnd **94** completes one revolution, the rotary star wheel **93** advances one-twelfth of a revolution bringing the appropriate hour indicia **97** to a mid-point position between the extremes of window **99**, which position corresponds with the time on the hour.

Other time indicator means also could be employed, particularly an indicator means suited for eliminating an additional element from the clock with consequent reduction in manufacturing costs. Thus as seen in FIGURE 2, the hour hand or other hour indicator device can be eliminated in favor of an indicia marking **165** applied directly to the face of the rotary star wheel, the marking **165** when adjacent the respective characters **12** on the clock face serving to denote the hour time.

From the foregoing description those skilled in the art will appreciate that the speed changer mechanism of the present invention is useful for a wide range of purposes. For example, the mechanism can be utilized in mechanical counters and meters. In the case of a water meter, the mechanism can be easily adapted to provide a quantity reading in gallons and tenths of a gallon by modifying the rotary star wheel and fixed frame structure accordingly. With the teaching of the present invention in mind, it should occur to those skilled in the art that a plurality of mechanisms could be used to achieve speed reduction of large magnitude. For example, three mechanisms could be employed in a train to produce a speed reduction of 1:1728 r.p.m. in which case the movement of the rotary star wheel of the FIGURE 7 mechanism could be employed to drive the output shaft of a like second mechanism in the train with the rotary star wheel in the latter driving the output shaft of a third like mechanism. When used in a clock the advantages of the mechanism are many particularly from the standpoint of reducing manufactur-

ing costs. Its simplicity of construction readily lends itself to incorporation into present clock manufacturing practices without requiring unusual tooling or reworking of existing clock structures. For example, the eccentric **17** can be formed as an integral part of the clock movement output shaft **14**. Tools for forming on a mass production basis the edge surfaces **33** on the rotary star wheel and the camming surfaces **34–44** on the plate **11** are of simpler construction than conventional gear cutting tools since, because of the open circular form of these surfaces, they can be cut with ordinary rotary cutters. Finally, it will be readily apparent that known means for resetting the clock hands can be incorporated in the mechanism with facility.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above construction and different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. Mechanism for unidirectionally rotating a second driven member at differential speed from a first driving member about a common central area within which is located a fixed axis about which the first member rotates, the mechanism comprising

an eccentric,

a rotary frame member mounted on said eccentric constituting said second member and being rotatable on its own axis independently of rotative movement of said eccentric, said rotary frame member carrying a circle of equally spaced projections at the periphery thereof, the projections being equidistant from the axis of said rotary frame member,

frame structure encircling said rotary frame member and carrying a circle of equally spaced fixed camming surfaces, the number of said camming surfaces being less than the number of projections carried on said rotary frame member, said camming surfaces being equidistant from said fixed axis, said eccentric being connected with said first member to rotate in unison therewith about said fixed axis whereby rotation of said eccentric produces bodily orbital movement of said rotary frame member about said fixed axis moving the projections thereon into and out of engagement with the camming surfaces on said fixed frame structure,

each engagement of a projection with a camming surface being effective to impart rotary movement to said rotary frame member about its own axis and in the same direction as said first member during the period of said engagement producing speed differential between said first and said second members.

2. The mechanism of claim **1** wherein said rotary frame member is a rotary star wheel, the projections carried thereby being defined by the intersection of adjacent ones of a corresponding number of curved surfaces formed in the periphery of said star wheel and arranged symmetrically about the central axis of said star wheel, said frame structure comprising a plate having a central aperture therein, said camming surfaces extending around said aperture, said camming surfaces comprising a number of curved surfaces formed in said plate and defining said aperture, said last-mentioned curved surfaces being arranged symmetrically about said fixed axis.

3. The mechanism of claim **2** wherein the curved surfaces formed in said rotary star wheel curve in the direction of the central axis of said rotary star wheel, and the curved surfaces formed in said plate curve in a direction away from said fixed axis.

4. Mechanism for unidirectionally rotating a second driven member at differential speed from a first driving member about a common central area within which is located a fixed axis about which the first member rotates, the mechanism comprising

an eccentric,

a rotary frame member mounted on said eccentric constituting said second member and being rotatable on its own axis independently of rotative movement of said eccentric, said rotary frame member carrying a circle of N equally spaced projections at the periphery thereof, the projections being equidistant from the axis of said rotary frame member,

frame structure encircling said rotary frame member and carrying a circle of N–1 equally spaced fixed camming surfaces, said camming surfaces being equidistant from said fixed axis, said eccentric being connected with said first member to rotate in unison therewith about said fixed axis whereby rotation of said eccentric produces bodily orbital movement of said rotary frame member about said fixed axis moving the projections thereon into and out of engagement with the camming surfaces on said fixed frame structure,

each engagement of a projection with a camming surface being effective to impart rotary movement to said rotary frame member about its own axis and in the same direction as said first member during the period of said engagement producing speed differential between said first and said second members.

5. The mechanism of claim **4** wherein N–12 providing a ratio of rotary frame projections to frame structure camming surfaces effective to produce a speed in said rotary frame member of one-twelfth of a revolution about its own axis for each complete revolution of said first member about said fixed axis.

6. Clock mechanism for unidirectionally rotating a second driven member at differential speed from a first driving member about a common central area within which is located a fixed axis about which the first member rotates, the mechanism comprising

an eccentric,

a rotary star wheel mounted on said eccentric constituting said second member and being rotatable on its own axis independently of rotative movement of said eccentric, said rotary star wheel carrying a circle of equally spaced projections at the periphery thereof, the projections being equidistant from the axis of said rotary frame member, and being defined by the intersection of adjacent ones of a corresponding number of curved surfaces formed in the periphery of said star wheel and arranged symmetrically about the central axis of said star wheel,

a plate having a central aperture therein encircling said rotary star wheel and carrying a circle of equally spaced fixed camming surfaces, the number of said camming surfaces being less than the number of projections carried on said rotary star wheel, said camming surfaces being equidistant from said fixed axis and comprising a number of curved surfaces formed in said plate and defining said aperture, said second-mentioned curved surfaces being arranged symmetrically about said fixed axis, said eccentric being connected with said first member to rotate in unison therewith about said fixed axis whereby rotation of said eccentric produces bodily orbital movement of said rotary star wheel about said fixed axis moving the projections thereon into and out of engagement with the camming surfaces on said plate,

each engagement of a projection with a camming surface being effective to impart rotary movement to said rotary star wheel about its own axis and in the same direction as said first member during the period of said engagement producing speed differential between said first and said second members said first member comprising the output shaft of a clock movement, a minute time indicator fixed to said shaft, said plate having time designation indicia thereon adjacent said central aperture, and an hour time indicator associated with said rotary star wheel.

7. The clock mechanism of claim **6** wherein said rotary star wheel is provided with a hub, the hour time indicator being an hour hand fixed to said hub.

8. The clock mechanism of claim **6** wherein the hour time indicator is a clock hand mounted loosely on said minute hand shaft, said hour hand having pins extending outwardly therefrom parallel with said minute hand shaft, said rotary star wheel having face openings therein for receiving said pins thereby drivingly connecting the hour hand with said rotary star wheel.

9. The clock mechanism of claim **6** wherein the hour time indicator comprises separate hour designation indicia on the face of said rotary star wheel, and a cover member fixed to said plate and covering said rotary star wheel, said cover member having a window therein with which said separate hour designation indicia register when said rotary star wheel rotates about its own axis.

10. The clock mechanism of claim **6** wherein the hour time indicator is an indicia marking carried on the face of said rotary star wheel.

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