May 25, 1965 G. W. LOHF ETAL 3,184,909

EPICYCLIC CLOCK DRIVE MECHANISM 2086

Filed Oct. 30, 1963 3 Sheets-Sheet 1

Fig. 1

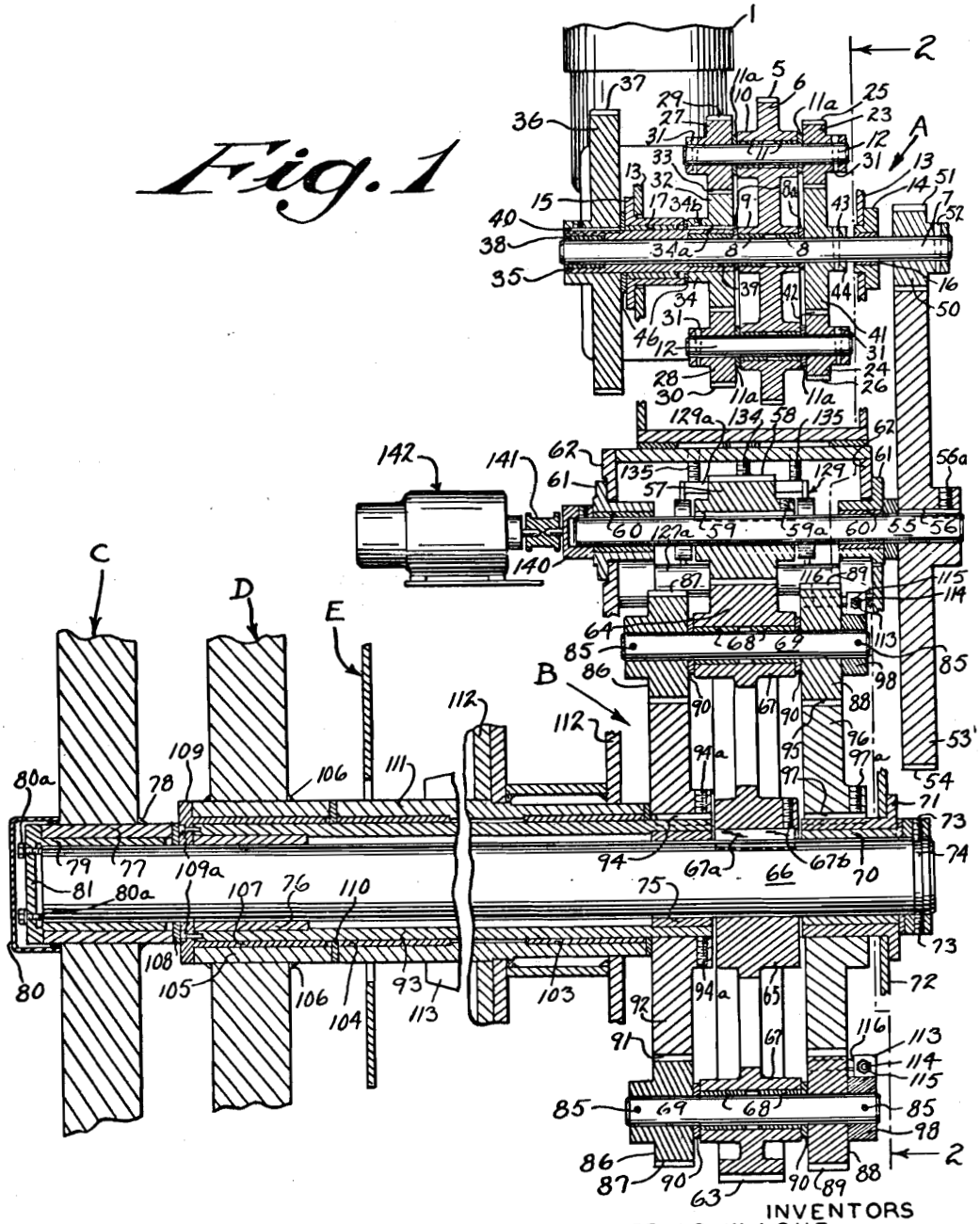

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Fig. 2

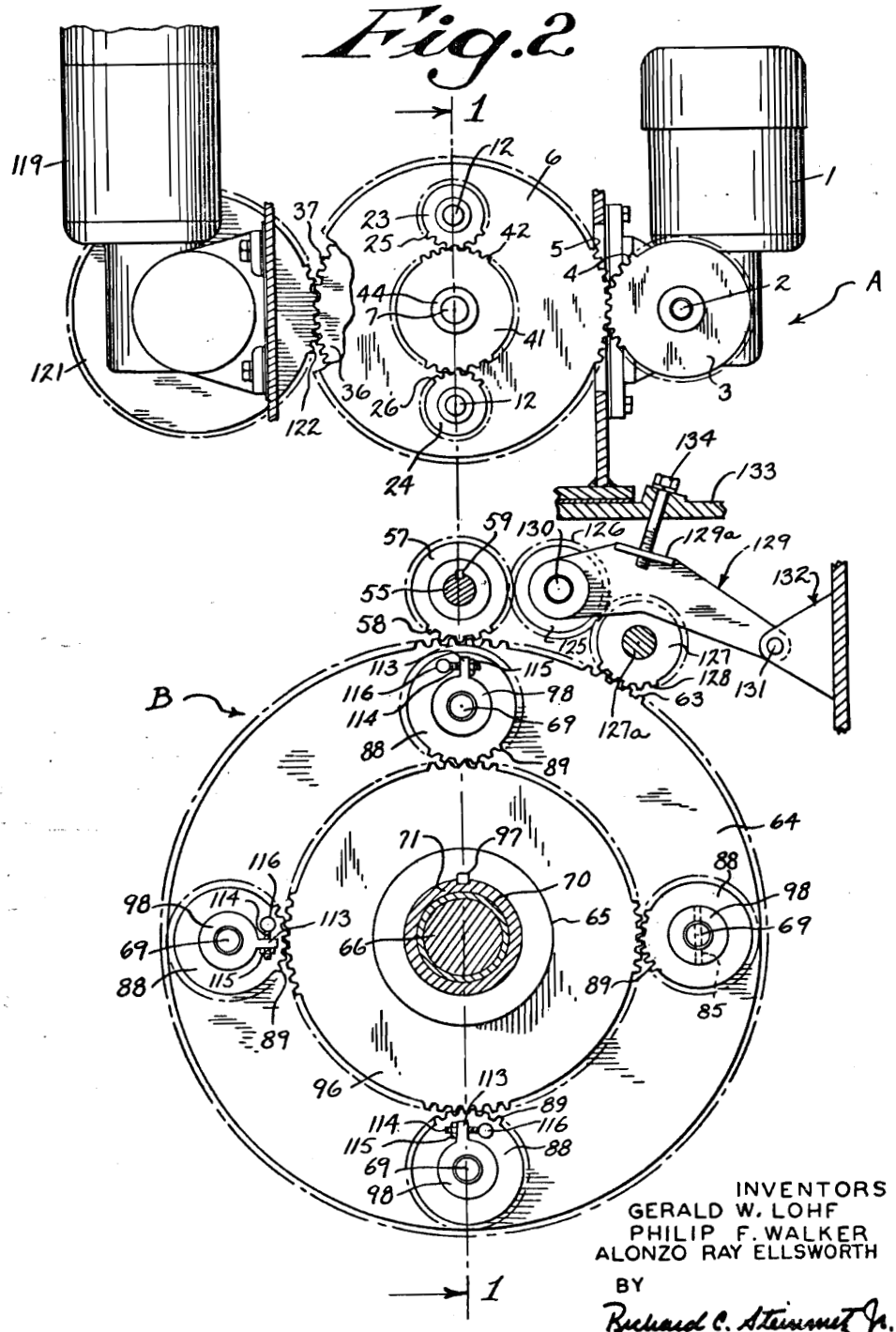

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Fig. 5

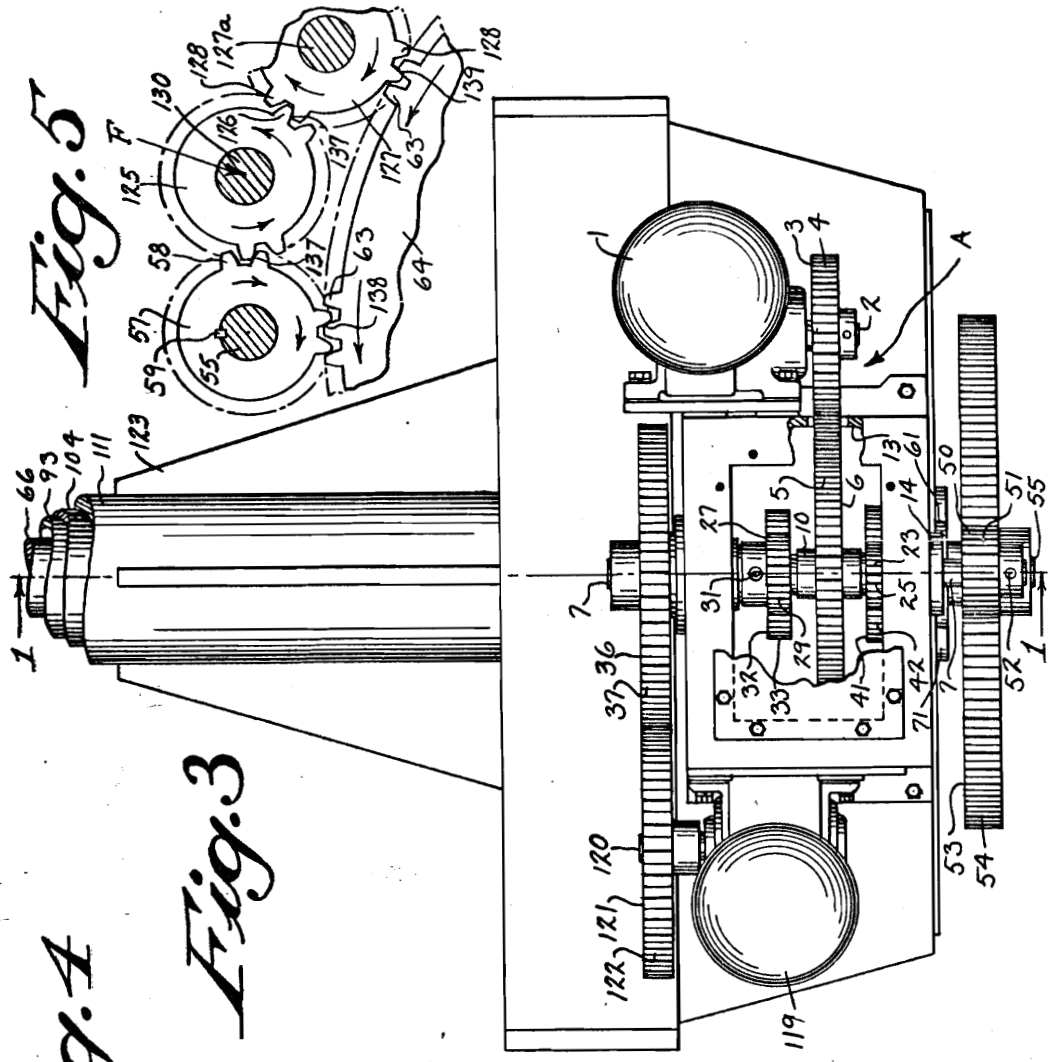
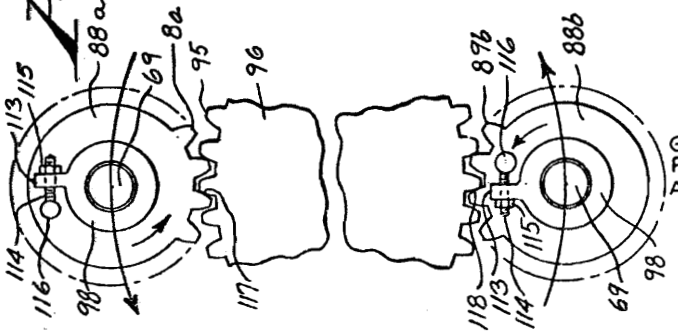


Fig. 3

Fig. 4



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EPICYCLIC CLOCK DRIVE MECHANISM

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10 Claims. (Cl. 58—2)

This invention is related to an improved clock mechanism, in particular, a mechanism for use in a clock tower. As will be appreciated by those skilled in the horology art, the particular use for this invention creates unique problems, e.g. size, accessibility, accuracy, etc. However, these problems have been overcome by the clock mechanism which is more specifically set forth in the following description and claims. The present mechanism generally includes not only an improved drive mechanism, but also a positive backlash prevention structure as well as means for setting the clock whether or not it is running.

Therefore, one object of this invention is to provide a simple, yet efficient, clock mechanism to be used particularly in a tower clock.

Another object of this invention is to provide a means for setting a clock in a most expeditious manner regardless of whether the clock is running in a minimum of time.

Another object of this invention is to provide positive and separate backlash prevention means for both hands on the clock.

A further object of this invention is to provide backlash prevention means for an epicyclic gear train.

Other objects of the invention are and will become apparent from the specification herein.

FIG. 1 is a cross-sectional, side view taken along line 1—1 of FIG. 2 and shows the clock mechanism including the gear trains for both driving and setting the clock hands.

FIG. 2 shows a cross-sectional, fragmentary, backside view of the clock mechanism taken along line 2—2 of FIG. 1.

FIG. 3 is a fragmentary top view of the clock mechanism.

FIG. 4 is an illustration of backlash prevention means adapted for use with the pinion and sun gear of an epicyclic gear train.

FIG. 5 is an illustration of backlash prevention means at the point of introducing energy into a gear train.

While the drawings depict a specific clock mechanism, these drawings are considered only illustrative such that the invention of this application is not limited thereto.

Before turning to the details of the drawings, it should be noted that the invention basically comprises two epicyclic gear trains designated as A and B, which trains are used to drive a minute hand C and an hour hand D of a tower clock which includes a clock face E. The gear train B serves the function of a dial train as used in the horology art.

The power train will first be described, i.e. the transmission of energy from synchronous motor 1 to minute hand C and hour hand D. The synchronous motor 1, which is standard and well known so that further description is not considered necessary, drive shaft 2 to which reducer gear 3 and gear teeth 4 thereof are attached (as best seen in FIG. 2). The gear teeth 4 of reducer gear 3 mesh in a driving relationship with gear teeth 5 of spider gear 6 which rotates about shaft 7 on cylindrical bearings 8. These bearings 8 abut the inside cylindrical surface of hub 9 which is at the center of spider gear 8 and which, in turn, abuts thrust bearings 8*a* at either end. Spider gear 8 also includes peripheral

hubs 10 in which cylindrical bearings 11 are located and through which shafts 12 pass. Main shaft 7 is supported at either end by the clock housing, depicted in FIG. 1 as housing support elements 13, which elements support bushings 14 and 15. Bearings 16 and 17 are located inside bushings 14 and 15, respectively. The particular structure surrounding main shaft 7 at the bushing 15 end thereof will be described in more detail later.

Pinned to the end of shafts 12, on one side of spider gear 6, are differential pinions 23 and 24 with gear teeth 25 and 26, respectively. Larger differential pinions 27 and 28 with gear teeth 29 and 30, respectively, are pinned to the other end of shaft 12. These pinions 23, 24, 27 and 28 are pinned to the shaft 12 by means of taper pins 31, as best shown in FIG. 1, and are separated from the peripheral hubs 10 by thrust bearings 11*a*. The gear teeth 33 of sun gear 32 mesh with gear teeth 29 and 30 of pinions 27 and 28, respectively, while the hub 34 of sun gear 32 is attached to concentric shaft 35 by means of key 34*a* and set screw 34*b*; the shaft 35 also being attached to time setting gear 36 with gear teeth 37 by key 40 and set screw 40*a* (see FIG. 1). As is further evident from FIG. 1, cylindrical bearings 38 and 39 separate main shaft 7 from concentric shaft 35 which in turn rides in cylindrical bearing 17 while thrust bearing 46 is inserted between time setting gear 36 and bushing 15. On the opposite side of spider gear 6, sun gear 41 meshes with teeth 25 and 26 of pinions 23 and 24, respectively, through its own gear teeth 42 and is attached to main shaft 7 at hub 44 by taper pin 43.

In order to transfer rotational energy from gear train A to gear train B, main shaft 7, driven by attached sun gear 41, rotates drive pinion 50 with gear teeth 51 since the shaft is attached to said gear 50 by means of taper pin 52. Drive pin 50 thereby turns intermediate drive gear 53 with gear teeth 54, which results in shaft 55 rotating through the connection therebetween by means of key 56 and set screw 56*a* (see FIG. 1). Attached to an intermediate portion of shaft 55 is pinion 57 with gear teeth 58, said attachment achieved through key 59 and set screw 59*a*. The shaft 55 is journaled in bearings 60 which are to be found in bushings 61 supported by the clock housing elements which are depicted here as support elements 62.

The gear teeth 58 mesh with gear teeth 63 of spider gear 64 so as to impart rotation to the latter and, consequently, gear train B. Spider gear 64 is similar to spider gear 6 with the exceptions that it is larger, that its center hub 65 is attached to minute hand shaft 66 by key 67*a*, along with set screws 67*b*, and that it has four peripheral hubs 67 each with bearings 68 therein and shafts 69 therethrough. The minute hand shaft 66 is journaled in bearing 70 located in bushing 71 which is supported by the clock housing elements, and which are identified by the reference numeral 72. Lateral movement of the minute hand shaft 66 is prevented by set screws 73 and groove 74 (see FIG. 4). Minute hand shaft 66 is also journaled in intermediate bearing 75 as well as bearing 76 and is keyed (not shown) to minute hand C through concentric tubular piece 77 to which said minute hand is attached, for example by welds 78. End caps 80 and 81 provide desired protection and finish while the concentric tubular member 79 of cap 80 serves as a spacer. Bolts 80*a* secure the cap 80 to minute hand shaft 66.

Returning to the periphery of the spider gear 64 and FIG. 1, taper pins 85 connect shafts 68 with differential pinions 86 having gear teeth 87 as well as one larger differential pinion 88 with gear teeth 89 (as shown in the "3 o'clock" position in FIG. 2). The remaining three pinions 88 are free to rotate on shafts 69 as will be explained later in connection with backlash prevention. It is important to note, however, that each of the pinions 88 has

a collar 98 pinned to shaft 69 by pins 85. Thrust bearings 90 are inserted between each of the pinions 86 and 88, and the peripheral hubs 67 of spider gear 64. Meshing with the gear teeth 87 of differential pinions 86 (see FIG. 1) are gear teeth 91 of sun gear 92 which is keyed to concentric shaft 93 at 94 (along with set screw 94*a*). The gear teeth 89 of larger pinions 88 mesh with gear teeth 95 of sun gear 96 which is keyed at 97 to bushing 71 and is therefore fixed. Set screw 97*a* is used to maintain the fixed relationship between sun gear 96 and bushing 71.

Concentric shaft 93 is journaled between bearings 75 and 76 on the inside and bearings 103 and 104 on the outside and is keyed (not shown) to hour hand D through the concentric tubular piece 105 to which the hour hand is attached, for example by weld 106. Concentric tubular member 107 of head piece 109 acts as a spacer, and bolts 109*a* secure piece 109 to hour hand shaft 93. Thrust bearing 108 is inserted between piece 77 and head piece 109 while thrust bearing 110 is inserted between piece 105 and concentric tubular housing 111 which is supported by the clock housing as depicted here by 112. The fins 123, as best shown in FIG. 3, provide structural support for the shafts 65 and 93.

Considering gear train A, again, and specifically the time setting mechanism, a squirrel cage induction motor 119 with drive shaft 120 (see FIG. 3) is used to turn time setting gear 36 through gear 121 and gear teeth 122 thereon with shaft 120 being attached to the latter gear. Included with the squirrel cage motor 119 is a magnetic brake (not shown) so as to maintain positive control over sun gear 32 through the gear train made of gears 121 and 36.

Positive backlash prevention is independently provided for both the hour hand shaft 93 and the minute hand shaft 66 with FIG. 4 illustrating the principle which applies to the hour hand shaft. In FIG. 4, a fragment of fixed sun gear 96 with teeth 95 along with pinions 88 with gear teeth 87 are shown as pinions 88*a* and 88*b* with teeth 89*a* and 87*b*, respectively (the reference characters *a* and *b* being used for explanatory purposes). As has been mentioned above, the pinions 86 and one pinion 88 along with its collar 98 are pinned to shafts 69 by taper pins 85 (see FIG. 1) while three pinions 88 have been considered free to rotate on shafts 69. Extending from the collars 98 for said three free pinions 88, the collars being pinned to shafts 69 by pins 85, are lugs 113 with tapped holes therein, through which set screws 114 pass and are held in place by nut 115. Thru pins 116 are attached to the pinions 88 (see FIG. 1) and extend axially therefrom in order to abut the set screws 114 as best shown in FIG. 4.

FIG. 4 illustrates, in a simplified form, how this above-described structure, i.e. collars 98, pinions 88, lugs 113, set screws 114, nuts 115 and pins 116, can be used to prevent backlash in the epicyclic gear train of this invention. Remembering that shafts 69 are rotating with spider gear 64, pinions 88*a* and 88*b* thereby rotate counterclockwise as indicated by the arrows through shafts 69 (FIG. 4). Pinion 88*a* meshes with sun gear 96 through teeth 89*a* at 117 in a manner which attempts to drive sun gear 96 in a clockwise direction. Note that this face contact at 117 is maintained by set screw 114 abutting against pin 116 of pinion 88*a*. Pinion 88*b*, on the other hand, meshes with sun gear 96 at 118 which includes the reverse drive face of pinion teeth 89*b*, with set screw 114 adjusted to abut pin 116 and thereby maintain the face contact at 118. Thus, pinions 88*a* and 88*b* are positively located with respect to shafts 69 as predetermined opposing forces are applied to sun gear 96 at points 117 and 118.

This backlash prevention scheme of FIG. 4 has been adopted by this invention, but in a more sophisticated manner which will be best understood from FIG. 2. Here the pinions of FIG. 4 with their particular gear teeth

meshing are shown as pinions 88 at the "12 o'clock and "6 o'clock positions which pinions are being used to duplicate the opposing forces created by the set screws 114 abutting pins 116 in the pinions 88 to be found in the "3 o'clock" and 9 o'clock" positions. In order to facilitate assembly of the epicyclic gear train of this invention, the pinion 88 at "3 o'clock" is constructed without the lug 113, etc. and is pinned to shaft 69 passing therethrough, thus providing an assembly starting point for establishing the necessary gear teeth relationship between each pinion 88 and sun gear 96. As will be understood, it is not necessary that directly opposite pinions, e.g. 88*a* and 88*b* of FIG. 4, form the bases for the opposing forces which result from adjustment of set screws 114, i.e. adjacent pinions could also provide these same opposing forces.

Because every force has an equal and opposite force, the resultant force of each pinion 88 against fixed sun gear 96 is transmitted as a torque through shafts 69 to differential pinions 86 which are themselves pinned to shafts 69 (see FIG. 1). Thus, by locating these pinions 86 so that their teeth 87 mesh with the teeth 91 of sun gear 92 in the particular face to face relationship illustrated by FIG. 4 and at the same time utilizing, at least this last mentioned mesh, the shaft torque created by the resultant force of pinions 88 against the gear teeth 95 of sun gear 96, sun gear 92 will be positively located by pinions 86, thereby preventing backlash in sun gear 92 and error in hour hand shaft 93.

The above-described backlash prevention means may also be used in gear train A as the positive relationship between shafts 12 and pinion 23, 24, 27 and 28 is established by means of pinning each pinion to the shafts after the necessary face contact relationship of gear teeth has been established, i.e. as shown in FIG. 4. While the set screws 114 and thru pins 116 of gear train B could be used in gear train A, the effect of minute and hour hand error created through backlash at this point in the gear train will be nominal, thus eliminating the need for such fine adjustment.

Minute hand error attributed to backlash is similarly prevented through the addition of intermediate idler 125 with gear teeth 126 and idler 127 with gear teeth 128 rotating on shaft 127*a* (FIG. 2). Since the spider gear 64, which is directly connected to the minute hand C through shaft 66, is to be positively located, gear teeth 128 of idler 127 contact gear teeth 63 of spider 64 at 139 (FIG. 5) in the same manner as gear teeth 87*b* of idler 86*b* contact gear teeth 91 of sun gear 92 at 118 in FIG. 4. This relationship is established when drive pinion 57, as shown in FIGS. 2 and 5, rotates clockwise so as to drive spider gear 64 at 138 (FIG. 5) in a counterclockwise direction.

Intermediate idler 125 is thereby driven in a counterclockwise direction by means of idler 127 (driven by spider gear 64) since the intermediate idler 125 is positively located between drive pinion 57 and idler 127 by force F on shaft 130 (see FIG. 5). Specifically, this force F will impose intermediate idler 125 upon both drive pinion 57 and idler 127 as the lower faces of teeth 126 (as viewed in FIG. 5) abut pinion teeth 58 at 136 and idler teeth 128 at 137.

Arm 129, which carries intermediate idler 125 on shaft 130 so as to provide the force F, is pivoted at 131 with the pivot point being connected to the clock housing (exemplified here by the reference numeral 132) and is secured to a horizontal portion of the clock housing (exemplified here by the reference numeral 133) through bolt 134. Set screws 135 (shown only in FIG. 1) maintain as well as provide fine adjustment of the force F on the intermediate idler 125 by abutting against plate 129*a* at one end while being secured (not shown) in housing support 133 at the other end.

Should it be desired to monitor the clock mechanism during normal operation and periods of time setting, a

Selsyn motor 142 is provided for transmitting the rotation speed of shaft 56 transferred via coupling 141 and cap 140, the latter being attached to the shaft 56. Since Selsyn motors are well known in the art, a detailed description of operation will not be made except to point out that it is possible to use a second Selsyn motor as a receiver for the information transmitted by 142 and thereby reproduce the clock motion at a location apart from the clock.

In operation, the synchronous motor 1 drives shaft 2 and consequently reducing gear 3 which meshes with spider gear 6 for rotation thereof. Spider gear 6 rotates about shaft 7 on bearings 8 and further causes differential pinions 23 and 24 to rotate about sun gear 41 as well as causing differential pinions 27 and 28 to rotate about sun gear 32. During normal operation, i.e. when the hands are not being set, sun gear 32 is held stationary through control of squirrel cage motor 119 and the magnetic brake while the differential gear sizes permits sun gear 41 to, itself, rotate which imparts motion to shaft 7 attached thereto. Shaft 7 turns drive pinion 50 which transfers its motion to intermediate drive gear 53 keyed to shaft 56. Also keyed to shaft 56 is drive pinion 57 which meshes with spider gear 64 thus completing the transfer of energy from gear train A to gear train B.

The rotation of spider gear 64 is divided two ways in gear train B. First, key 67*a* directly connects center hub 65 of spider gear 64 with minute hand shaft 66 so that the rotating speed of spider gear 64 is also that of minute hand C. Secondly, sun gear 94 turns hour hand shaft 93 which is directly connected to hour hand D. The sun gear 92, itself, rotates as a result of the circular motion of differential pinions 86 and 88 about hub 65 of spider gear 64 combined with the rotation of differential pinions 86, resulting from the rotation of differential pinion 88 on fixed sun gear 96.

When it is necessary to set the clock hands C and D, the magnetic brake associated with squirrel cage motor 119 is released causing gear 121 to rotate time setting gear 36. Since the latter gear is keyed to concentric shaft 35, which is in turn keyed to sun gear 32, the net result is increased rotational speed for sun gear 32 so as to speed up pinion 27 and/or 28, as the case may be. This increased speed is transmitted through shaft 12 to the normal power train of gear trains A and B, previously described. As will be noted, this structure permits setting of the clock hands while the ordinary clock drive mechanism continues to function. It should also be noted that by using a reversible squirrel cage motor, the clock hands may be moved forward or backward. In an actual reduction to practice of this clock mechanism, the hands of the clock can be set ahead one hour in a time interval of 59 seconds and can be retarded one hour in a time interval of 61 seconds.

Thus, it is evident that the above-described invention is a most significant contribution to the art.

We claim:

1. In a clock mechanism for a tower type clock having an hour hand shaft and a minute hand shaft combined with a dial train which supplies substantial torque to said shafts, said dial train comprising,

(*a*) drive means for a spider gear means which gear means is attached at a center hub thereof to said minute hand shaft,

(*b*) said spider gear means comprising at least one gear shaft hub near the periphery thereof,

(*c*) gear shaft means located in each gear shaft hub and free to rotate therein,

(*d*) first and second differential pinion means attached to each gear shaft,

(*e*) first sun gear means attached to said hour hand shaft which is concentric with said minute hand shaft, and

(*f*) a second sun gear means attached to a fixed shaft concentric with said minute hand shaft,

(*g*) said first and second differential pinion means in rotatable contact with said first and second sun gear means respectively.

2. In a clock mechanism for a tower type clock having an hour hand shaft and a minute hand shaft combined with a dial train which supplies substantial torque to said shafts, said dial train comprising,

(*a*) drive means for a spider gear means which is attached at a center hub thereof to said minute hand shaft,

(*b*) said spider gear comprising a plurality of gear shaft hubs near the periphery thereof,

(*c*) gear shaft means located in each of said gear shaft hubs and free to rotate therein,

(*d*) pinion means attached to each gear shaft with the axis of said pinion means being parallel to the axis of said minute hand shaft,

(*e*) said pinion means on one side of said spider gear means being smaller in diameter than those pinion means on the other side of said spider gear means,

(*f*) first sun gear means attached to said hour hand shaft which is concentric with said minute hand shaft, and in rotatable contact with said smaller pinion means, and

(*g*) a second sun gear means attached to a fixed shaft in axial alignment with said minute hand shaft, and in rotatable contact with said larger pinion means.

3. In combination with the clock mechanism of claim 1, means to prevent backlash in said spider gear, and hence said minute hand shaft, comprising:

(*a*) pinion drive means intermediate said drive means and said spider gear means,

(*b*) idler gear means meshing with said spider gear means,

(*c*) intermediate idler gear means which mesh with both said pinion drive means and said idler gear means, and

(*d*) means to urge said intermediate idler gear means against said pinion drive means and said idler gear means so as to prevent backlash in said spider gear.

4. In combination with the clock mechanism of claim 1, means to prevent backlash in said first sun gear means, and hence said hour hand shaft, comprising:

(*a*) lug means extending radially from a collar of said second differential pinion means contacting said second sun gear which pinion means are free to rotate on said gear shaft with said collar being secured to said gear shaft,

(*b*) said lug means including a bore transverse to the axis of said pinion means,

(*c*) pin means attached to said second differential pinion means and extending axially therefrom, and

(*d*) set screw means rotatively secured in each lug hole and abutting the pin means thereof for positively locating said differential pinion means with respect to said gear shaft means and thereby preventing backlash in said first sun gear.

5. In combination with the clock mechanism of claim 1, means to prevent backlash in both said spider gear, and hence said minute hand shaft, as well as said first sun gear means, and hence said hour hand shaft comprising:

(*a*) pinion drive means intermediate said drive means and said spider gear means,

(*b*) idler gear means meshing with said spider gear means,

(*c*) intermediate idler gear means which mesh with both said pinion drive means and said idler gear means,

(*d*) and means to urge said intermediate idler gear means against said pinion drive means and said idler gear means so as to prevent blacklash in said spider gear means,

(*e*) lug means extending radially from a collar of said second differential pinion means contacting said second sun gear which pinion means are free to ro-

tate on said gear shaft with said collar being secured to said gear shaft,

(*f*) said lug means including a bore transverse to the axis of said pinion means,

(*g*) pin means attached to said second differential pinion means and extending axially therefrom, and

(*h*) set screw means rotatively secured in each lug hole and abutting the pin means thereof for positively locating said differential pinion means with respect to said gear shaft means and thereby preventing backlash in said first sun gear.

6. In combination with the clock mechanism of claim 1, a time setting mechanism with a time setting shaft means comprising:

(*a*) second drive means for a second spider gear means which gear means rotates freely on a second drive shaft means through a center hub thereof,

(*b*) said second spider gear means comprising at least one gear shaft hub near the periphery thereof,

(*c*) second gear shaft means located in each gear shaft hub of said second spider gear means and free to rotate therein,

(*d*) third and fourth differential pinion means attached to each of said second gear shaft means,

(*e*) third sun gear means attached to said drive shaft means and engaging said third differential pinion means,

(*f*) fourth sun gear means attached to said time setting shaft means concentric with said drive shaft means and engaging said fourth differential pinion means,

(*g*) time setting means connected to said time setting shaft means so as to permit rotation of said time setting shaft and said fourth sun gear only during periods of time setting, and

(*h*) intermediate drive means connecting said second drive shaft means and said dial train.

7. In the combination of claim 6.

(*a*) said second drive means comprising a synchronous motor means and an attached reducer gear means which drives said second spider gear means, and

(*b*) said time setting means comprising a squirrel cage motor means and associated brake means.

8. In combination with the mechanism of claim 3, a time setting mechanism with a time setting shaft means comprising:

(*a*) second drive means for a second spider gear means which second gear means rotates freely on a drive shaft means through a second center hub thereof,

(*b*) said second spider gear means comprising at least one gear shaft hub near the periphery thereof,

(*c*) second gear shaft means located in each gear shaft hub of said second spider gear means and free to rotate therein,

(*d*) third and fourth differential pinion means attached to each of said second gear shaft means,

(*e*) third sun gear means attached to said drive shaft means and engaging said third differential pinion means,

(*f*) fourth sun gear means attached to said time setting shaft means concentric with said drive shaft means and engaging said fourth differential pinion means,

(*g*) time setting means connected to said time setting shaft means so as to permit rotation of said time setting shaft and said fourth sun gear only during periods of time setting, and

(*h*) intermediate drive means connecting said second drive shaft means and said dial train.

9. In combination with the mechanism of claim 4, a time setting mechanism with a time setting shaft means comprising:

(*a*) second drive means for a second spider gear means which gear means rotates freely on a second drive shaft means through a center hub thereof,

(*b*) said second spider gear means comprising at least one gear shaft hub near the periphery thereof,

(*c*) second gear shaft means located in each gear shaft hub of said second spider gear means and free to rotate therein,

(*d*) third and fourth differential pinion means attached to said second gear shaft means,

(*e*) third sun gear means attached to said drive shaft means and engaging said third differential pinion means,

(*f*) fourth sun gear means attached to said time setting shaft means concentric with said drive shaft means and engaging said fourth differential pinion means,

(*g*) time setting means connected to said time setting shaft means so as to permit rotation of said time setting shaft and said fourth sun gear only during periods of time setting, and

(*h*) intermediate drive means connecting said second drive shaft means and said dial train.

10. In combination with the mechanism of claim 5, a time setting mechanism with a time setting shaft means comprising:

(*a*) second drive means for a second spider gear means which gear means rotates freely on a second drive shaft means through a center hub thereof,

(*b*) said second spider gear means comprising at least one gear shaft hub near the periphery thereof,

(*c*) second gear shaft means located in each gear shaft hub of said second spider gear means and free to rotate therein,

(*d*) third and fourth differential pinion means attached to said second gear shaft means,

(*e*) third sun gear means attached to said drive shaft means and engaging said third differential pinion means,

(*f*) fourth sun gear means attached to said time setting shaft means concentric with said drive shaft means and engaging said fourth differential pinion means,

(*g*) time setting means connected to said time setting shaft means so as to permit rotation of said time setting shaft and said fourth sun gear only during periods of time setting, and

(*h*) intermediate drive means connecting said second drive shaft means and said dial train.

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LEO SMILOW, *Primary Examiner.*