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"GEAR TRAIN MECHANISM FOR A WATCH"

This invention relates to a gear train mechanism for a watch and, although the invention is not so restricted, it relates more particularly to a gear train mechanism for a quartz crystal watch.

5 According to the present invention, there is provided a gear train mechanism for a watch comprising a plate; a tubular member mounted in said plate; a gear train bridge; a seconds gear which is rotatably mounted in the gear train bridge and which is adapted to drive a seconds hand; a further
10 gear driven by the seconds gear; a centre gear adapted to drive a minutes hand and driven by the further gear, the centre gear being provided with a support shaft which is rotatably mounted within the tubular member; a minute gear
15 driven by the centre gear; an hour gear which is driven by the minute gear and which is adapted to drive an hour hand, the hour gear being rotatably mounted on the tubular member; and the centre gear having an axial bore therethrough within which a shaft portion of the seconds gear is rotatably supported at one region only.

20 Preferably there is a radial gap not exceeding 25μ between the bore of the tubular member and the support shaft.

 There is also preferably a radial gap not exceeding 25μ between the shaft portion and the axial bore of the support shaft in said region.

There may be a radial gap of at least 50 μ between the shaft portion and the axial bore of the centre gear except at said region.

5 The support shaft may have an outwardly extending portion which extends outwardly of the tubular member and which is adapted to be provided with the said minute hand, the said region being disposed adjacent to the outwardly extending portion.

10 Preferably, both the further gear and the minute gear are rotatably mounted both in said plate and in said gear train bridge.

15 A stepping motor may be provided having a rotor which drives the seconds gear by way of another gear, said rotor and said other gear being rotatably mounted both in said plate and in said gear train bridge.

The mechanism preferably comprises a clutch wheel which is movable into and out of an operative position in which rotation of the clutch wheel adjusts the minute gear, whereby to adjust the position of the hands of the watch.

20 The invention also comprises a watch, e.g. a quartz crystal watch, provided with a gear train mechanism as set forth above.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:-

25 Figure 1 is a broken-away cross-sectional view of one

known gear train mechanism for a watch,

Figure 2 is a broken-away cross-sectional view of another known gear train mechanism for a watch,

5 Figure 3 is a diagram illustrating the pressures to which certain parts of the known mechanisms have been subjected,

Figures 4 and 5 are broken-away cross-sectional views of a first embodiment of a gear train mechanism according to the present invention, and

10 Figure 6 is a broken-away cross-sectional view of a second embodiment of a gear train mechanism according to the present invention.

Throughout the description below, similar reference numerals are used to indicate similar parts.

15 Terms such as "upper" and "lower", as used in the description below are to be understood to refer to directions as seen in the drawings.

Two known gear train mechanisms for a quartz crystal wrist watch are shown respectively in Figures 1 and 2.

20 The gear train mechanism of Figure 1 is designed to make a watch thin. In Figure 1, 1 is a plate, 2 is a gear train bridge, 3 is a centre wheel bridge, 5 is a rotor of a stepping motor, 6 is a fifth wheel and pinion, 7 is a seconds wheel and pinion, 8 is a third wheel and pinion and 9 is a centre wheel and pinion. In this

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construction, the plate 1 and the gear train bridge 2
are indispensable. The centre wheel bridge 3 is merely
provided to hold a support shaft 4 for supporting the
centre wheel and pinion 9 and to receive pressure at the
5 time when an hour hand (not shown) is fitted. The centre
wheel bridge is at least 0.3mm thick and the space provided
for the movement must therefore allow for this. In order to
make the movement as thin as possible, the gear train bridge 2
and the plate 1 are made extremely thin by a complex milling
10 process. Consequently the manufacturing cost of the watch
is increased because of the high processing cost of the
gear train bridge 2 and of the plate 1, and the additional
cost for extra members such as the centre wheel bridge 3.

15 In the gear train mechanism of Figure 2, 1 is a plate,
2 is a gear train bridge, 5 is a rotor of a stepping motor,
6 is a fifth wheel and pinion, 7 is a seconds wheel and
pinion, 8 is a third wheel and pinion and 9 is a centre
wheel and pinion. 15 and 16 are stators provided respectively
above and below a rotor magnet 5a. The stators 15 and 16
20 and the rotor magnet 5a constitute a stepping motor. The
fifth wheel and pinion 6 is rotatably supported by a
support shaft 13 which is mounted in the gear train bridge
2. The centre wheel and pinion 9 is rotatably supported
by a tubular member 14. 10 represents a part of a minute wheel
25 which meshes with the centre pinion 9. A tenon or shaft
portion 7c of the seconds wheel and pinion 7 adjacent to
gear train bridge 2 (hereinafter referred to as the upper
tenon) is rotatably supported by the gear train bridge 2, and

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another tenon or shaft portion 7d adjacent to the plate 1 (hereinafter referred to as the lower tenon) is supported by an axial bore 9c of the centre wheel and pinion 9 at two regions where the lower tenon 7d has enlarged diameter portions 7a, 7b.

In the structure of Figure 2, there are two major disadvantages. Firstly, the fifth wheel and pinion 6 is supported by means of the support shaft 13. This increases the number of assembly steps and therefore increases the manufacturing cost. Moreover, because of the way in which they are supported, the fifth wheel 6, the seconds wheel 7, and the third wheel 8 overlap one another, so that the movement becomes thicker. Further, when compared with a structure in which the upper and lower tenons of the fifth wheel and pinion 6 are rotatably supported by the gear train bridge 2 and by the plate 1 respectively, there are greater energy losses from friction at the bearing. As a fifth wheel has a small rotating torque like a rotor, even a slight loss of torque can cause the watch to stop.

A second disadvantage of the construction of Figure 2 is that the seconds wheel and pinion 7 is supported at three points, namely at the upper tenon 7c by the gear train bridge 2, and at the two enlarged diameter portions 7a, 7b of the lower tenon 7d by the axial bore 9c of the centre wheel and pinion 9.

If a calendar mechanism is incorporated into this structure,

a load arising from the calendar is put onto the centre wheel and pinion 9 through the minute wheel 10 engaging therewith, and this causes the centre wheel and pinion 9 to become inclined. As a result, the enlarged diameter portion 7b of the seconds wheel and pinion 7 is pressed against the axial bore 9c and friction at this point imposes a load on the seconds wheel and pinion 7. This is illustrated in quantitative terms below.

In a man's watch, the driving torque at the minute hand is usually 3 to 4g-cm. On the assumption that the driving torque of the motor at the centre wheel and pinion is 3.5g-cm and that the power transmission efficiency for the seconds wheel and pinion 7 to the centre wheel and pinion 9 is 80%, the driving torque at the seconds wheel and pinion 7 is 0.073g-cm.

If the pitch circle of the centre pinion 9 is 1.8mm and if the load arising from the provision of a calendar which is put upon the centre wheel and pinion 9 is 0.5g-cm, then the lateral pressure upon the enlarged diameter portion 7b of the seconds wheel and pinion 7 is 5.56g. The load torque on the seconds wheel and pinion 7 due to the lateral pressure can be evaluated, as shown in Figure 3, by assuming certain sizes for the various parts of the mechanism.

Figure 3 illustrates diagrammatically the region adjacent to the seconds wheel and pinion 7. 7 is the seconds wheel and pinion, 9 is the centre wheel and pinion, A is a point where

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the seconds wheel and pinion 7 is supported by the gear train bridge 2, B is a point where the seconds wheel and pinion 7 contacts the centre wheel and pinion 9 to which a lateral pressure F is applied from the minute wheel 10, C is a point where the centre wheel and pinion 9 is supported by the plate 1, and D is a point where the seconds wheel and pinion 7 contacts the centre wheel and pinion 9. f_1 , f_2 , and f_3 are pressures acting on the seconds wheel and pinion 7 at the points A, B and D respectively. f_4 is the pressure of the plate 1 upon the centre wheel and pinion 9 at the point C. As shown in Figure 3, the distances between A and B, B and C and C and D are 1.0mm, 0.6mm and 1.2mm respectively. The actual calculation is not set out in detail here. When the lateral pressure F is 5.56g as mentioned before it can be shown that f_1 is 2.09g, f_2 is 3.25g, f_3 is 1.16g and f_4 is 3.47g. If the diameter of the upper tenon 7c of the seconds wheel and pinion 7 at the point A is 0.14mm and that at B and D is 0.35mm, and if the coefficient of friction is 0.2, the frictional load torque on the seconds wheel and pinion 7 due to pressures f_1 , f_2 and f_3 is 0.018g-cm in total.

The above frictional load torque is equal to 25% of the usual driving torque of a motor which is transmitted to the second wheel and pinion 7. Thus, a loss of as much as 25% of the driving torque is incurred in the gear train

structure shown by Figure 2. Moreover, the above calculation assumes the best conditions. In reality, however, there are many other problems such as the flection and eccentricity of the tubular member 14 mounted in the plate 1, the flection and eccentricity of the axial bore 9c of the centre wheel and pinion 9, the flection of the seconds wheel and pinion 7, the eccentricity of the tenon 7c which is journalled in the gear train bridge 2, the eccentricity of the axial bore of the tubular member 14, and so on. The factors mentioned above can cause rubbing between the seconds wheel and pinion 7 and the centre wheel and pinion 9 so that the watch stops.

An object of this invention is to eliminate the foregoing disadvantages.

Figures 4 and 5 are broken-away cross-sectional views of different parts of a first embodiment of a gear train mechanism according to the present invention. As shown therein, the mechanism comprises a plate 23, 24; a tubular member 14 mounted in the plate 23, 24; a gear train bridge 2; a seconds gear, or seconds wheel and pinion, 7 which is rotatably mounted in the gear train bridge 2, the seconds wheel and pinion 7 having a shaft portion 7d whose lower end carries a seconds hand (not shown); a third gear 8 which is driven by the seconds wheel and pinion 7; a centre gear, or centre wheel and pinion, 9 which is driven by the third

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gear 8, the centre wheel and pinion 9 being provided with a support shaft 9b which is rotatably mounted within the tubular member 14; a minute gear 20 driven by the centre wheel and pinion 9; and an hour wheel 11 which is driven by the minute gear 20 and which drives an hour hand (not shown), the hour gear 11 being rotatably mounted on the tubular member 14. The support shaft 9b has an outwardly extending portion 9d which extends outwardly of the tubular member 14 and which is provided with a minutes hand (not shown). Both the third gear 8 and the minute gear 20 are rotatably mounted both in the plate 23, 24 and in the gear train bridge 2.

A rotor 5 of a stepping motor drives the seconds wheel and pinion 7 by way of a fifth wheel and pinion 6, both the rotor 5 and the fifth wheel and pinion 6 being rotatably mounted both in the plate 23, 24 and in the gear train bridge 2.

A setting wheel 12 meshes with the minute gear 20 and is adapted to mesh with a clutch wheel 22 which is axially movable and rotatable by a stem 21. The stem 21 and clutch wheel 22 are shown in Figure 5 in their inoperative positions. When, however, the stem 21 is pushed towards the left as seen in Figure 5, the clutch wheel 22 is moved into an operative position in which it meshes with the setting wheel 12. Thus rotation of the clutch wheel 22 in the operative

position adjusts the minute gear 20 and thus adjusts the positions of the hands of the watch.

5 In the embodiment shown in Figures 4 and 5, the plate 23, 24 consists of metal portions 23, which are provided to reinforce the plate, and plastics portions 24 which are combined with the metal portions 23 by injection moulding. This enables a support shaft 24a for the setting wheel 12 and an opening 24b for guiding the stem 21 to be formed of plastics, whereas these parts would be difficult to form of metal.

10 The upper tenon or shaft portion 7c of the seconds wheel and pinion 7 is rotatably supported by the gear train bridge 2. A surface 7e of the seconds wheel and pinion 7 is in contact with an end surface 9e of the centre wheel and pinion 9, so as to support the latter against thrust. The lower tenon or shaft portion 7d thereof is radially and rotatably supported by the axial bore 9c which extends through the centre wheel and pinion 9. The shaft portion 7d has an enlarged diameter portion 7a so that the shaft portion 7d is so rotatably supported at one region only, namely at the enlarged diameter portion 7a. Thus the seconds wheel and pinion 7 is supported at two points, namely at 7a and 7c. As will be seen in Figures 4 and 5, the enlarged diameter portion 7a is disposed below the plate 23, 24 and thus on the side of the latter remote from the gear train bridge 2. The diameter of the axial bore 9c of the centre wheel and pinion 9 is about 0.35mm. There is a radial gap not exceeding 25μ between the shaft portion 7d and the axial bore 9c of the support shaft 9b at the enlarged diameter portion 7a, and there is a radial gap of at least 50μ between the shaft portion 7d and the axial bore 9c of the support shaft 9b except at the enlarged diameter portion 7a. There is also a radial gap not exceeding 25μ between the bore of the tubular member 14 and

the support shaft 9b. It will be noted that the enlarged diameter portion 7a is disposed adjacent to the outwardly extending portion 9d of the support shaft 9b.

5 Since the centre wheel and pinion 9 is rotatably supported by the tubular member 14, if counter force from the minute gear 20 and so on is applied to the centre wheel and pinion 9, the centre wheel and pinion 9 does not become inclined, and there is no effect on the seconds wheel and pinion 7. Even if the centre wheel and pinion 9 is forced by the minute gear 20 to become inclined within the tubular member 14, the seconds wheel and pinion 7 is not affected because of the gap between the axial bore 9c and the shaft portion 7d of the seconds wheel and pinion 7. Therefore, any lateral pressure applied to the supporting points constituted by the enlarged diameter portion 7a and the upper tenon 7c of the seconds wheel and pinion 7 is caused only by the weight of the seconds wheel and pinion 7 itself, the effect of the fifth wheel pinion 6, the counter force produced when driving the third wheel and pinion 8 and the like. Roughly calculated, about 0.0011g-cm is lost by friction at the seconds wheel and pinion 7, which is equal to only 1.5% of the driving torque at the seconds wheel and pinion 7 and incomparably less than what is lost in the known constructions.

25 Further, in the embodiment of Figures 4 and 5, the fifth wheel 6 and the third wheel are aligned horizontally, and the seconds wheel 7 is disposed above the fifth and the third wheels 6, 8. As a result, the movement is thinner than

in the Figure 2 structure in which all the three wheels 6, 7, 8 are in different horizontal planes.

As shown in Figure 5, a minute wheel 20a of the minute gear is disposed above a centre wheel 9a of the centre wheel and pinion 9, the setting wheel 12 engaging with the minute wheel 20a and being engageable with the clutch wheel 22. Thus there is no need to provide any extra wheels to effect drive between the minute wheel 20a and the clutch wheel 22. Also, the stem 21 can be provided very close to the dial (not shown) of the watch. In order to make the watch thinner, it is important that the stem 21 should be close to the dial. For example, a watch whose total thickness is 5.5mm may have a movement whose thickness is 2.5mm and a stem which is spaced by 1mm from the dial. In such a watch, the stem may be 3.4mm from the upper surface of the cover glass (not shown) of the watch and 21mm from the case back of the watch. If the diameter of a crown carried by the stem is 3.5mm, the distance from the crown to the upper surface of the cover glass is 1.65mm and that from the crown to the case back is 0.35mm. Since the distance from the crown to the case back is so short, the flank of the case back cannot be cut to form a slope, which gives the watch a bad appearance. Therefore, in a thin movement, the stem should be as close as possible to the dial.

Figure 6 shows another embodiment of the present invention which is similar to the embodiment of Figures 4 and 5

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except that the clutch wheel 22 is directly engageable with the minute wheel 20 without the intermediary of a setting wheel. This embodiment has the disadvantage that the distance through which the stem 21 can be moved is short, that is, there is little room to permit the crown to be drawn out to enable the stem to have a plurality of different functions. However, the Figure 6 construction has the advantage that it is very simple because a setting wheel is dispensed with and the stem 21 can be disposed very close to the dial, as in the embodiment of Figures 4 and 5.

The embodiments described above therefore enable the watch to be made thin and provide a stem which is close to the dial. These embodiments have simple constructions so as to reduce manufacturing costs. The friction of the gear train of these embodiments is much less than in the known gear trains. In the embodiments described above, a bipolar stepping motor is used and a fifth wheel and pinion is provided between a rotor of the stepping motor and a second wheel and pinion. If, however, a multipolar stepping motor which employs a small stepping angle is used instead, the seconds wheel and pinion can be directly engaged with the rotor without providing a fifth wheel and pinion therebetween. Alternatively, if desired, two or more wheels and pinions can be provided between the rotor and the seconds wheel and pinion.

As will be appreciated from the above description, in the conventional gear train mechanism shown in Figure 2, a centre wheel and pinion 9 is rotatably supported by a support shaft of a seconds wheel and pinion 7 at the two supporting points 7a and 7b. In this structure, the counter force which is produced when the centre wheel 9 drives the minute wheel 10, acts upon the supporting points 7a, 7b and a frictional load is imposed on the seconds wheel and pinion 7. As a result, 20% to 30% of the driving power of the motor 5 is lost by the friction at these points. For example, the driving torque at the centre wheel 9 is only 3.5 to 4g-cm while it should be 5g-cm. Applying this to the power consumption of the motor, what is uselessly consumed is, for example 0.3 to 0.45 μ A with respect to the total power consumption 1.5 μ A. In other words, a battery having an additional capacity of 20 to 30% is required in the above-mentioned structure. This prevents the watch being made thinner and smaller.

In the embodiments of Figures 4 and 5 and of Figure 6. However, the centre wheel and pinion 9 rotatably support the shaft of the seconds wheel and pinion 7 at one supporting point only. So, if the centre wheel and pinion 9 leans within the gap between the centre wheel and pinion 9 and the tubular member 14 supporting it, the centre wheel and pinion 9 contacts the shaft of the seconds wheel and pinion 7 only at one point. Therefore, the external force imposed on the centre wheel and pinion 9 has no effect on the seconds wheel and pinion 7 and thus the loss of driving torque is largely reduced.



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C L A I M S

1. A gear train mechanism for a watch comprising a plate; a tubular member mounted in said plate; a gear train bridge; a seconds gear which is rotatably mounted in the gear train bridge and which is adapted to drive a seconds hand; a further gear driven by the seconds gear; a centre gear adapted to drive a minutes hand and driven by the further gear, the centre gear being provided with a support shaft which is rotatably mounted within the tubular member; a minute gear driven by the centre gear; an hour gear which is driven by the minute gear and which is adapted to drive an hour hand, the hour gear being rotatably mounted on the tubular member; and the centre gear having an axial bore therethrough within which a shaft portion of the seconds gear is rotatably supported at one region only.
2. A mechanism as claimed in claim 1 in which there is a radial gap not exceeding 25μ between the bore of the tubular member and the support shaft.
3. A mechanism as claimed in claim 1 or 2 in which there is a radial gap not exceeding 25μ between the shaft portion and the axial bore of the support shaft in said region.
4. A mechanism as claimed in any preceding claim in which there is a radial gap of at least 50μ between the shaft portion and the axial bore of the centre gear except at said region.



5. A mechanism as claimed in any preceding claim in which the support shaft has an outwardly extending portion which extends outwardly of the tubular member and which is adapted to be provided with the said minute hand, the said region being disposed adjacent to the outwardly extending portion.

6. A mechanism as claimed in any preceding claim in which both the further gear and the minute gear are rotatably mounted both in said plate and in said gear train bridge.

7. A mechanism as claimed in any preceding claim comprising a stepping motor having a rotor which drives the seconds gear by way of another gear, said rotor and said other gear being rotatably mounted both in said plate and in said gear train bridge.

8. A mechanism as claimed in any preceding claim comprising a clutch wheel which is movable into and out of an operative position in which rotation of the clutch wheel adjusts the minute gear, whereby to adjust the position of the hands of the watch.

9. A mechanism as claimed in any preceding claim in which the said shaft portion has a single enlarged diameter portion which is radially and rotatably supported in the said axial bore and which is disposed on a side of said plate remote from said gear train bridge.



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10. A mechanism as claimed in any preceding claim in which a surface of the seconds gear is in contact with an end surface of the centre gear 9.

11. A gear train mechanism for a watch substantially as hereinbefore described with reference to Figures 4 and 5 or with reference to Figure 6 of the accompanying drawings.

12. A watch provided with a mechanism as claimed in any preceding claim.

13. A watch as claimed in claim 12 in which the watch is a quartz crystal watch.

14. A gear train mechanism for a quartz crystal wrist watch comprising a plate, a centre pipe mounted on said plate, a gear train bridge, a second wheel and pinion, a third wheel and pinion, a centre wheel and pinion, a minute wheel and an hour wheel, said hour wheel being provided rotatably around said centre pipe, said centre wheel and pinion being rotatably supported inside of said centre pipe, said second wheel and pinion being rotatably supported by said gear train bridge and a support shaft of said centre wheel and pinion, and the gap between said second wheel and pinion and said support shaft of said centre wheel and pinion being narrow at one portion, a shaft portion of the second wheel and pinion being rotatably supported only at said narrow one portion in said support shaft of said centre wheel and pinion.