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(54) STEPPER MOTOR FOR A QUARTZ CRYSTAL TIMEPIECE

(71) We, KABUSHIKI KAISHA SUWA SEIKOSHA, a Japanese Company, of 3-4, 4-chome, Ginza, Chuo-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to stepper motors for quartz crystal timepieces.

According to one aspect of the present invention there is provided a stepper motor for a quartz crystal timepiece comprising: a driving coil; a permanently magnetised rotor; and a stator core portion disposed to direct magnetic flux produced by current flowing in the driving coil to a position in which it interacts with the magnetic flux produced by the rotor to cause the latter either to rotate or to oscillate the stator core portion consisting of a pair of stator polepieces fixed to and in engagement with a member of smaller magnetic permeability than the stator polepieces.

The said member may be formed of non-magnetic material.

Both stator polepieces may be permanently fixed to the said member. Alternatively one stator polepiece may be permanently fixed to the said member, and the other stator polepiece may be adjustably secured to the said member so that its position relative to said one stator polepiece may be altered.

According to a further aspect of the present invention there is provided a quartz crystal timepiece having a stepper motor as recited above.

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

Figure 1 is a plan view of a conventional stepper motor for a quartz crystal timepiece;

Figure 2 is a plan view of a stator core portion of one embodiment of a stepper motor according to the present invention for a quartz crystal timepiece.

Figure 3 is a sectional view of the stator core portion of Figure 2, and

Figure 4 is a plan view of a stator core portion of another embodiment of a stepper motor according to the present invention.

Referring to Figure 1 there is shown, in plan, a conventional stepper motor for a quartz crystal timepiece. The conventional stepper motor consists of a pair of stator polepieces 1, 2 disposed about a rotor 3. The position of the stator polepieces 1 can be adjusted relative to the rotor by means of an eccentric pin 4 which forces the stator polepiece 1 to pivot about a pin 4'. Similarly, the position of the stator polepiece 2 can be adjusted relative to the rotor by means of an eccentric pin 5 which causes the stator polepiece 2 to pivot about a pin 5'. The stator polepieces 1, 2 are fixed to a plate 10 by screws 6, 7, 8, 9 after their position relative to the rotor has been adjusted using the eccentric pins 4, 5.

As is well known, in such a stepper motor the stator polepieces 1, 2 constitute a magnetic path for magnetic flux which is generated in a core 14 of a driving coil 11 in response to a current pulse appearing at an output terminal 12 or an output terminal 13 of a driving circuit and applied to the coil 11. The rotor 3, which is permanently magnetised, will rotate due to the interaction between the magnetic field generated in a gap between pole faces 1a, 2a of the stator polepieces 1, 2 respectively and the magnetic field of the rotor.

It is necessary that the rotor 3 rotates in a stable manner and through a predetermined angle on the application of each current pulse to the driving coil 11. This is influenced by, inter alia, the com-

plex relationship between the magnetomotive force of the driving coil 11, the magnetic pole strength of the rotor 3, the size of the gaps 15, 16 between the stator polepiece 1 and the rotor, the size of gaps 17, 18 between the stator polepiece 2 and the rotor, the size of gaps 19, 20 between the stator polepieces 1, 2, and the relative position of the stator polepieces 1, 2 as indicated by gaps 21, 22. Accordingly, it is necessary to adjust the position of the stator polepieces 1, 2 using the eccentric pins 4, 5 after the stepper motor is assembled, to check the size of the gaps 15, 16, 17, 18, 19, 20, 21, 22, and to observe the rotation of the rotor 3 and the waveform of current flowing in the driving coil 11 when the current pulses are applied thereto. To adjust the position of the stator polepieces after the stepper motor has been assembled requires the eccentric pins 4, 5 to be moved from outside of a bridge (not shown) which supports the rotor. Moreover, this bridge must be so constructed that, for example, the gaps 15, 16, 17, 18, 19, 20, 21, 22 are not obscured thereby. Thus nothing can be disposed upon the bridge. In the case where the stator polepieces are adjusted according to the waveform of the current pulses flowing in the driving coil special devices and/or tools must be used. Thus adjustment of this conventional stepper motor is complicated, time consuming and a relatively large space is required to permit such adjustment. Furthermore, in the case of after-sales service of a quartz crystal timepiece incorporating this conventional stepper motor, similar complicated and time consuming adjustments have to be performed especially if the stator polepieces have to be removed, or if their positions have been changed by an external shock applied to the quartz crystal timepiece.

Figures 2 and 3 illustrate a stator core portion of a stepper motor according to the present invention for a quartz crystal timepiece. Parts of the stepper motor not shown in Figures 2 and 3 may be similar to those of the conventional stepper motor of Figure 1. The stator core portion comprises a pair of stator polepieces 101, 102 which are formed as a unitary body and fixed to a non-magnetic stator substrate 123 by welding or other suitable means. Subsequently gaps 119, 120 are cut in the unitary body to form the stator polepieces 1, 2. Although the gaps 119, 120 separate the stator polepieces 1, 2 the positions of the stators polepieces relative to one another is constant by virtue of the fact that they are both fixed to the stator substrate 123. The stator core portion can be mounted on a plate or other fixed struc-

ture by suitable means passing through apertures 124, 125 in the same manner as the bridge of the conventional stepper motor. As a result of forming the stator polepieces in this manner, it is possible to predetermine, within a relatively small tolerance, the size of the gaps 15, 16, 17, 18, 19, 20, 21, 22, shown in Figure 1. Accordingly, the rotor will rotate in a stable manner and the stepper motor can be such as to require substantially no regulation.

It will be appreciated that the stator substrate 123 may not only be in the form a plate as shown, but may be of other constructions and has a smaller magnetic permeability than the stator polepieces.

Figure 4 illustrates a stator core portion of another embodiment of a stepper motor according to the present invention for a quartz crystal timepiece. Again the parts of the stepper motor not shown in Figure 4 may be similar to those of the conventional stepper motor of Figure 1. A stator polepiece 201 is fixed to a stator substrate 223 by guide pins 227, 228 by welding or other suitable means. A stator polepiece 202 is fixed to the stator substrate 223 after gaps 221, 222 between the stator polepieces 201, 202 have been adjusted to a predetermined size by an adjusting eccentric pin 205. The stator core portion is mounted on a plate or other fixed structure by suitable means passing through apertures 224, 225. When the stator polepieces 201, 202 have been fixed to the stator substrate, no further adjustment of their position relative to one another is necessary. The stator polepieces may be heated without affecting the stator substrate and this means that the stator substrate can be made of one or more of a number of different materials as long as the stator substrate has a smaller magnetic permeability than the stator polepieces.

It will be appreciated that it is possible to unify a plate and a pair of stator polepieces by fixing the stator polepieces to the plate directly and not to a stator substrate, again as long as the plate has a smaller magnetic permeability than the stator polepieces. Alternatively, a stepper motor which needs no adjustment during after-sales service can be provided by fixing an adjusting member by means of welding, adhering, caulking, wedging etc., after adjustment of the position of the stator polepieces has been effected.

Though the stepper motors according to the present invention described above are of the type in which the rotor rotates stepwise in one direction through a predetermined angle, the present invention is also applicable to stepper motors of the type in which the rotor performs an oscil-

lating movement through a predetermined angle.

WHAT WE CLAIM IS:—

- 5 1. A stepper motor for a quartz crystal
timepiece comprising: a driving coil; a
permanently magnetised rotor; and a stator
core portion disposed to direct magnetic
flux produced by current flowing in the
10 driving coil to a position in which it in-
teracts with the magnetic flux produced by
the rotor to cause the latter either to rotate
or to oscillate the stator core portion con-
sisting of a pair of stator polepieces fixed
15 to and in engagement with a member of
smaller magnetic permeability than the
stator polepieces.
2. A stepper motor as claimed in claim
1 in which the said member is formed of
20 non-magnetic material.
3. A stepper motor as claimed in claim
1 or 2 in which both stator polepieces are
permanently fixed to the said member.

4. A stepper motor as claimed in claim
1 or 2, in which one stator polepiece is 25
permanently fixed to the said member, and
the other stator polepiece is adjustably
secured to the said member so that its
position relative to said one stator
polepiece may be altered. 30

5. A stepper motor for a quartz crystal
timepiece substantially as herein described
with reference to and as shown in Figures
2 to 4 of the accompanying drawings.

6. A quartz crystal timepiece having a 35
stepper motor as claimed in any preceding
claim.

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stator polepieces.
2. A stepper motor as claimed in claim
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20 non-magnetic material.
3. A stepper motor as claimed in claim
1 or 2 in which both stator polepieces are
permanently fixed to the said member.

4. A stepper motor as claimed in claim
1 or 2, in which one stator polepiece is 25
permanently fixed to the said member, and
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5. A stepper motor for a quartz crystal
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