

DRIVE UNIT FOR A ROTARY DECORATION

The present invention relates to a drive unit for a rotary decoration applied, for example, to a table clock with a rotary decoration.

A table clock with a rotary decoration is popular as a highly decorative high-grade table clock. A rotary decoration constituting a main component of the table clock with a rotary decoration is usually mounted rotatably on a vertical shaft, so as to cause a swing movement around this vertical shaft in a horizontal direction. A hair spring or motor is used as a mechanism for causing a reciprocative swing movement of the rotary decoration.

A first example adopting a hair spring is, for example, constituted in such a manner that a rotary decoration is given the reciprocative swing movement by the application of the balance-wheel motor principle used in a transistor clock, while its rotational shaft is provided to be driven via the hair spring to cause a moderate sine curve, thus imparting an elegant motion to the rotary decoration. (For example, refer to the Japanese Utility Model Publication No. 21821 of 1985)

However, this hair spring type rotary decoration is disadvantageous in that it is accompanied with a complicated

design and manufacturing process and therefore it is not suited for mass production, and furthermore has a high parts cost, and is troublesome to install since careful attention is required in installing the hair spring.

The applicant of this application has proposed a second example of a stepping motor equipped type in the Japanese Patent Application No. 43718 of 1991, wherein a stepping motor capable of rotating in both the normal and reverse directions is adopted, and the drive timing of this stepping motor is controlled in such a manner that a rotary decoration can have a reciprocal swinging movement following substantially the same sine curve as arises when using a hair-spring.

The drive unit using the reciprocating motor described in the second example which controls a decoration so as to move it along a sine curve similar to the case where a hair spring is used is constituted by using a damper such as a coil spring in the transmission gear train so that a smooth rotational motion can be obtained in the decoration regardless of the stepping motor. However, this arrangement has the following three problems to be solved.

(1) In order to speed up a rotation period without varying the maximum swing angle θ_1 , it is normally required to reduce the interval d of an output pulse for driving a step motor. In other words, it is required that the pulse

interval d be shortened so that numerous pulses can be generated within a short period of time.

In view of the performance of the stepping motor, the minimum pulse interval $d_{\min}$ is restricted to a predetermined value. Therefore, the maximum pulse interval $d_{\max}$ must be made smaller.

If the maximum pulse interval $d_{\max}$ is reduced to a smaller value, the difference between the maximum pulse interval $d_{\max}$ and the minimum pulse interval $d_{\min}$ becomes small. Hence, the difference between the angular velocity $\omega_{\max}$ of the rotary decoration during low-speed rotation and the angular velocity $\omega_{\min}$ of the rotary decoration during high-speed rotation likewise becomes small. Thus, there is no crispness in the rotation of the rotary decoration.

Furthermore, if the maximum pulse interval $d_{\max}$ is reduced to a smaller value, the angular velocity ω cannot be sufficiently reduced when the rotary decoration changes its rotational direction. Namely, the rotary decoration starts to move fast from the beginning. As a result, the behavior of the rotary decoration looks awkward. And, therefore, there was a problem such that the elegant swing movement desired could not be given to the rotary decoration.

Moreover, if numerous pulses are generated within a limited short period of time, electric power consumption

increases and the life of the battery is shortened.

(2) When the rotary decoration changes its rotational direction, a coil spring is wound up. At the beginning of this winding up operation, the rotary decoration is stopped for a while, due to the fact that this coil spring is once loosened to a unwound-up condition, and wound up again. Accordingly, it was not possible to give the elegant swing movement desired to the rotary decoration.

(3) Even if the driving pulse for the stepping motor is suddenly stopped, the wound-up coil spring is gradually loosened. Therefore, the spring force stored in the coil spring is gradually given to the rotary decoration. Thus, the rotary decoration continues to rotate for a while due to its inertia.

Accordingly, even if a pulse for causing the stepping motor to rotate in the reverse direction is suddenly outputted so as to reverse the rotational direction of the rotary decoration, the rotary decoration maintains its rotational direction for a while by virtue of its inertia. As a result, the rotational driving force of the stepping motor and the inertia derived from the coil spring acting in the reverse direction interfere with each other. Thus, irregularities arise in the motion of the rotary decoration.

Consequently, the present invention seeks to provide a

drive unit for the rotary decoration which is capable of giving the elegant swing movement desired, even if a damper member such as a coil spring is configured in the transmission gear train.

5 Accordingly the present invention provides a drive unit for a rotary decoration, which drive unit causes the rotary decoration to rotate alternately in a forward and a reverse direction in a substantially sinusoidal manner, having a stepping motor coupled to
10 the rotary decoration through a damping circuit, a control circuit to control the movement of the stepping motor, and a memory circuit containing drive timing data relating to the time interval between successive movement steps of the stepping motor, wherein the
15 control circuit controls the movement of the stepping motor in accordance with the drive timing data in the memory circuit, and wherein the drive timing data is such that the magnitude of said time intervals varies in a non-sinusoidal manner.

20 For a better understanding of the present invention, and to show how it may be brought into effect, reference will now be made, by way of example, to the following drawings, in which:

 Figure 1 shows diagrammatically the relationship
25 between a rotary decoration and its rotational angle.

 Figure 2 is a wave form chart for operation pulses of a known rotary decoration drive unit.

 Figure 3 is a wave form chart showing operation pulses for a first embodiment of the present invention.

30 Figure 4 shows the relationship between the rotary decoration member and its rotational angle during operation of the first embodiment of the invention.

 Figure 5 is a wave form chart showing operation pulses for a second embodiment of the present
35 invention.

 Figure 6 shows the relationship between the rotary

decoration and its rotational angle during operation of a third embodiment of the invention.

Figure 7 is a wave form chart showing operation pulses in accordance with the third embodiment of the
5 present invention.

Figure 8 is a block diagram showing a circuit configuration.

Figure 9 is a partially cross-sectioned side view showing the specific configuration of the apparatus of
10 an embodiment of the invention.

Figure 10 is a cross-sectioned plan view showing the specific configuration of the apparatus of an embodiment of the invention.

The present invention basically aims to simulate the operation timing of the stepping motor driving the rotary decoration in order to cause the output shaft to realize a moderate speed change as if the rotary decoration were swinging by use of a hair spring. The moderate speed change of the rotary decoration will be explained with reference to Fig. 1.

In Fig. 1, a rotary decoration 5 is shown with the centre of its front surface aligned with a point P. The rotary decoration 5 rotates in a clockwise direction by an angle of $+\theta_1$ until it reaches a point P1, and then reverses its rotational direction (rotates in a counterclockwise direction) to return from the point P1 to the point P. Subsequently, this rotary decoration 5 rotates further in a counter direction by an angle of $-\theta_1$ until it reaches a point P2.

In this manner, the rotary decoration 5 causes a reciprocative swing motion having a cycle reciprocating between these three points P1, P, and P2 in an order of P -

P1 → P → P2 → P ----.

By causing the stepping motor to change its speed like a cosine curve having a predetermined period, it is possible to change the speed of the rotary decoration by the stepping motor in such a manner that the rotary decoration changes its speed like a sine curve.

As means for causing such a speed change, the operation pulse interval d is reduced for the stepping motor, as the angular velocity ω of the rotary decoration becomes large. Conversely, when the angular velocity ω of the rotary decoration is small, the operation pulse interval d is increased to a large value. (See, Fig. 2)

However, in a case where the rotary decoration 5 is controlled to swing like a sine curve, its transmission gear train is configured to include a damper member such as a coil spring which will be described later, in order to realize the smooth swing motion of the rotary decoration even if it is driven by a stepping motor.

In such a case, in order to speed up the rotation period without varying the maximum swing angle θ_1 , it is normally necessary to reduce the interval d of an output pulse for driving the stepping motor. In other words, it is necessary to shorten the pulse interval d so that numerous pulses can be generated within a limited period of time.

In view of the performance of the stepping motor, the

minimum pulse interval $d_{\min}$ is restricted to a predetermined value. Therefore, the maximum pulse interval $d_{\max}$ must be made smaller.

If the maximum pulse interval $d_{\max}$ is reduced to a smaller value, a difference between the maximum pulse interval $d_{\max}$ and the minimum pulse interval $d_{\min}$ becomes small. Hence, the difference between the angular velocity $\omega_{\max}$ of the rotary decoration during low-speed rotation and an angular velocity $\omega_{\min}$ of the rotary decoration during high-speed rotation likewise becomes small. Thus, variance in the rotation of the rotary decoration disappears.

Furthermore, if the maximum pulse interval $d_{\max}$ is reduced to a smaller value, the angular velocity ω cannot be sufficiently reduced when the rotary decoration changes its rotational direction. Namely, the rotary decoration begins to move fast from the beginning. As a result, the behavior of the rotary decoration looks awkward. And, therefore, there was a problem such that the elegant swing movement desired could not be given to the rotary decoration.

Moreover, if numerous pulses are generated within a short period of time, electric power consumption increases and the life of the battery is shortened.

In order to solve such a problem, the angular velocity should be accelerated and decelerated before and after the

rotary decoration 5 initiates its rotational movement and before and after the rotary decoration 5 stops its rotational movement, to drive the rotary decoration at a constant speed at the section where the rotary decoration rotates at its maximum speed; i.e. when it passes the middle section of its swing movement in one rotational direction.

In accordance with the first embodiment of the present invention, as shown in Fig. 3, pulse intervals are set to be the small, equal intervals within a predetermined section C in the middle section in the swing movement of the rotary decoration in one direction.

By adopting the pulse waveform shown in Fig. 3, the rotary decoration 5 is gradually accelerated in the direction of its normal rotation, and is driven at a constant speed in the middle section (i.e. a section between points P3 and

P4 in Fig. 4), and is gradually decelerated after passing this middle section.

Then, the pulses for driving the stepping motor in the reverse direction are outputted and reversal begins. Therefore, the rotary decoration 5 is gradually accelerated in a direction of its reverse rotation, and is driven at a constant speed in the middle section (i.e. the section between the points P3 and P4 in Fig.1), and then gradually decelerated after passing this middle section. This behavior repeats from this point on.

As described above, in a case where the pulse waveform shown in Fig. 2 is adopted, the rotary decoration 5 is gradually accelerated at the beginning of its swing motion in the normal direction and gradually decelerated once past a central point (i.e. the point P in Fig. 1).

However, in a case where the pulse waveform shown in Fig. 3 is adopted, the rotary decoration 5 can be decelerated within a smaller section; i.e. from the point where the rotary decoration has just passed the middle section to the apogee of rotation (i.e. a section from the point P3 to the point P1, or a section from the point P4 to the point P2).

Therefore, it becomes possible to complete the deceleration within a short period of time and therefore the rotary decoration 5 can have an elegant swing motion.

Next, a second embodiment of the present invention is explained with reference to accompanying drawings.

The coil spring is wound up when the rotary decoration 5 changes its rotational direction, that is, in Fig.4, when the rotary decoration 5 rotates in a clockwise direction by an angle of $\pm\theta_1$ until it reaches the point P1 and then reverses its rotational direction (i.e. rotates in a counterclockwise direction) to return from the point P1 to the point P. The rotary decoration 5 stops its rotational motion during the period of time required for loosening the wound coil spring

and for re-winding the coil spring. As a result, it becomes impossible to impart an elegant swing motion to the rotary decoration 5.

In order to solve such a problem, in accordance with the second embodiment of the present invention, as shown in Fig. 5,

the pulse interval becomes close in a predetermined section A immediately after the rotary decoration has changed its rotational direction. That is to say, by outputting driving pulses in a short period of time in the amount required to loosen the wound coil spring and then re-wind it, it becomes possible to promptly wind up the coil. As a result, the rotary decoration 5 is prevented from stopping at the time when the rotational direction of the rotary decoration 5 is changed. Thus, an elegant swing movement can be realized.

Next, a third embodiment of the present invention is explained with reference to the accompanying drawings.

Even if the driving pulse for the stepping motor is suddenly stopped, the wound-up coil spring is gradually loosened. Therefore, a spring force stored in the coil spring is gradually transmitted to the rotary decoration 5 and the decoration rotates for a while due to inertia.

Therefore, even if a pulse for rotating in the reverse direction is suddenly outputted so as to

reverse the rotational direction of the rotary decoration, the rotary decoration maintains its rotational direction for a while by virtue of its inertia. Therefore, the rotational driving force of the stepping motor and the inertia force derived from the coil spring acting in the reverse direction interfere with each other, thus, producing an awkward swing movement in the decoration.

In order to solve such a problem, in the third embodiment of the present invention, as shown in Fig. 7, a pulse is not outputted in a predetermined section B immediately before the rotary decoration 5 changes its rotational direction. That is, there is a no-pulse generating section prior to the rotary decoration 5 changing its rotational direction.

Accordingly, just before the rotary decoration 5 reaches this no-pulse generating section (i.e. the position P3 or P4 in Fig. 6), the wound up coil spring is gradually loosened and the rotary decoration rotates by virtue of its inertia. This loosened coil spring is wound up again in accordance with this inertial rotation. At the end of this rewinding-up operation, a pulse is inputted into the stepping motor.

Hence, there is no interference between the rotational driving force of the step motor and the inertia derived from the coil spring acting in the reverse direction. Furthermore, when the rotary decoration initiates its swing

movement in a reverse direction, the rotary decoration 5 has an elegant swing motion since the coil spring is completely wound up.

Fig. 8 is a block diagram showing a circuit configuration of the present invention. A memory circuit 31 stores data used for generating the above-described operation pulses, and is connected to a control circuit 32. The control circuit 32 can specify an address in the memory circuit 31 and read a numerical value corresponding to the pulse interval via a data bus from this specified address. Furthermore the control circuit 32 is connected with a clock circuit 32a for converting a pulse interval into a chronological element, and with a reset switch 32b for resetting the central processing unit 32. The control circuit 32 has two separate outputs, one (01) for rotating the motor in the normal direction, and the other (02) for rotating the motor in the reverse direction. They are each connected to a motor driving circuit 33 that contains respective output buffers. The motor driving circuit 33 is constituted in such a manner that a pulse interval is outputted to the stepping motor 9 in accordance with the pulse interval outputted from the control circuit 32.

When the rotary decoration 5 is actuated, the control circuit 32 specifies an address in the memory circuit 31,

which address corresponds to the starting operation of rotary decoration 5. A numerical value representative of pulse interval is read in via the data bus, and then an operation pulse causing rotational motion in the normal direction is supplied from the control circuit 32 to the motor driving circuit 33. The stepping motor 9 steps in accordance with an operation pulse for normal rotation sent by the drive timing. The rotational movement of the stepping motor 9 is transmitted from a rotor 12 to the gears 14, 15. A coil spring 18 (Fig. 9) is charged with spring force by the rotation of the gear 15. Then, by the spring force stored in the coil spring 18, a disk 17 is turned and a rotary shaft 3 is driven in the direction of a normal rotation through a transmission shaft 16 and a driving gear 8. As the rotational force is transmitted through the coil spring 18 in this manner, the rotational torque is smoothly transmitted to the disk 17, the driving gear 8, and the rotary shaft 3, even if the gear 15 is intermittently rotated to cause step motion. Thus, the rotary decoration 5 can be driven smoothly in a direction of normal rotation.

In this manner, the pulse signal is read out successively so as to have a drive timing corresponding to the rotational angle of the rotary decoration 5, so that the motor rotates to cause the rotary decoration 5 to swing in a normal swing direction. When, the rotary decoration 5 has

then rotated by an amount of $1/2$ its maximum angle of rotation, the control circuit 32 begins supplying reverse-rotation operation pulses to the motor driving circuit 33 on the basis of subsequently inputted data so that the motor rotates in the reverse direction. Then, the rotary decoration 5 is swung in the opposite direction again by an amount corresponding to the maximum angle of rotation, and in turn, the rotary decoration 5 is swung in the normal direction by an amount corresponding to the maximum angle of rotation. This cycle is reiterated and the rotary decoration 5 is driven in a reciprocative rotation.

Now, a driving device for the rotary decoration, that embodies the present invention, is explained.

As shown in Figs. 9 and 10, the rotary shaft 3 is rotatably supported vertically in the direction of gravity by an upper case 1 and a lower case 2 and further pivotally supported at bearing portions 1a and 2a thereof. The rotary shaft 3 extends through a center of a protrusion 4a of a middle plate 4. The rotary decoration 5 is secured on a protruding edge of the rotary shaft 3, which extends upward out of the upper case 1. Furthermore, a bush 3a is secured on the rotary shaft 3 between the upper case and the middle plate 4. A movable permanent magnet 6 is secured on this bush 3a. A stationary permanent magnet 7 is secured on the

protrusion 4a of the middle plate 4, so as to oppose the lower face of permanent magnet 6. These two permanent magnets 6, 7 are magnetized to mutually repel each other at their confronting surfaces. Their magnetic forces are constructed to set up a magnetic floating mechanism between the two permanent magnets 6, 7 in such a manner that both permanent magnets 6, 7 oppose each other through a predetermined gap in a non-contact condition when the rotary decoration 5 is mounted on the rotary shaft 3.

The drive gear 8 is connected downward from middle plate 4 with the protruding portion of the rotary shaft 3, so as to be slidable in an axial direction of the rotary shaft 3 but not to rotate with respect to the rotary shaft 3. A rotational force of the stepping motor 9, which serves as a driving source, is transmitted to the drive gear 8. That is to say, a drive coil 11 is wound around one leg piece of the stator 10, which is substantially formed in a U-shape. The rotor 12 is rotatably supported between the lower case 2 and the middle plate 4 in a gap provided at a front edge of the stator 10. A permanent magnet 13 secured on the rotor 12 functions to receive a rotational force by being magnetically coupled with the stator 10.

A rotor pinion 12a is meshed with the gear 14. A pinion 14a of this gear 14 is meshed with a gear 15. The gear 15 is rotatably engaged with the transmission shaft 16. Also, a

pinion 16a integrally formed with this transmission shaft 16 is meshed with the drive gear 8. With this arrangement, the transmission gear train is configured to start from the stepping motor 9 and reach the drive gear 8. The gears 15 and 16 are both rotatably supported between the lower case 2 and the middle plate 4.

Though the gear 15 is rotatably supported by the transmission shaft 16, the lower end portion of the transmission shaft 16 is press-fitted into a through-hole on the disk 17 so that this gear 15 is retained so as not to be removed from the transmission shaft 16. The coil spring 18 is interposed between the gear 15 and the disk 17, and an upper end of the coil spring 18 is fixed to the gear 15 and a lower end of the coil spring 18 is fixed to the disk 17.

On the lower surface of the gear 15, a protrusion 15a is integrally formed to extend downward to closely approach the outer peripheral portion of the disk 17. On the outer peripheral portion of the disk 17, a protrusion 17a is provided to partly protrude in a radial direction. When the coil spring 18 is in a free condition (neutral condition), the protrusion 15a and the protrusion 17a are positioned so as to oppose each other. The protrusion 15a and the protrusion 17a do not engage each other during a normal operation. Only when the coil spring 18 is excessively wound up, or when the coil spring 18 is excessively loosened, do

they act to prevent the coil spring 18 from being damaged.

A lock lever 20 is rotatably supported on the protrusion 2b, which is protrusively formed from the lower case 2 adjacent to the permanent magnets 6, 7. Moreover, a click arm 20a formed in a coaxial arc-shape, a locking arm 20b formed in a slant surface and extending in a radial direction, and a protrusion 20c protruding on the upper surface of the locking arm extending outwardly are integrally formed together with this locking lever 20. The locking arm 20b is capable of entering between the permanent magnets 6 and 7 and lifting the permanent magnet 6 upward by its slant surface.

Beneath the reset arm 20d, there is provided a printed circuit board 21 and both ends of the drive coil 11 are connected to the predetermined positions thereon. Furthermore, a spring plate 22, that constitutes the reset switch 32b for resetting the control circuit 32 as explained with reference to Fig. 8, is disposed at a position where the spring plate 22 confronts an edge portion of the reset arm 20d on the printed circuit board 21. Moreover, a click pin 19 is formed on the printed circuit board 21, so as to protrude thereon. The click arm 20a can move beyond this click pin 19.

As described above, a portion except for the magnetic floating mechanism corresponds to the stepping motor 9 and the

transmission gear train extending from this stepping motor 9. This transmission gear train is accommodated between the lower case 2 and the middle plate 4 and, therefore, it becomes possible to form the overall unit in a thin configuration. The portion housing the permanent magnets 6, 7; i.e. the portion of the magnetic floating mechanism, becomes thick in a up-and-down direction in Fig. 9 compared with the portion housing the transmission gear train. Therefore, the upper case 1 is formed with a protrusive portion 1b in a predetermined area about the rotary shaft 3. The magnetic floating mechanism including the permanent magnets 6, 7 is housed in a space 1c formed by this protrusive portion 1b. If it is supposed that the maximum angle of rotation of the rotary decoration 5 is $2\theta_1$, the angular velocity ω of the rotary decoration 5 is greatest when the rotary decoration 5 is positioned to face forward (the position P in Fig. 1); i.e. when its rotational angle is θ_1 . And, the angular velocity ω of the rotary decoration 5 is least when the rotary decoration 5 is positioned at both the right and left ends (the positions P1, P2 in Fig. 1). Accordingly, the pulse interval d of the operation pulse is set to the minimum interval $d_{\min}$ when the angular velocity ω is greatest. Conversely, the pulse interval d of the operation pulse is set to the maximum interval $d_{\max}$ when the angular velocity ω is least. Also, the pulse interval d of

the operation pulse is changed to decrease from the maximum interval $d_{\max}$ to the minimum interval $d_{\min}$. And also, the pulse interval d of the operation pulse is changed to increase from the minimum interval $d_{\min}$ to the maximum interval $d_{\max}$.

When the rotary decoration 5 is actuated, the control circuit 32 specifies the address in the read only memory 31, which address corresponds to the starting operation of rotary decoration 5. A numerical value representative of the pulse interval is read in via the data bus, and then the operation pulse causing a rotational movement in a normal direction is supplied from the control circuit 32 to the motor driving circuit 33. The stepping motor 9 steps in accordance with the operation pulse, which causes a rotational motion in a normal direction, supplied at a predetermined driving interval. The rotational motion of the stepping motor 9 is transmitted from the rotor 12 to the gears 14, 15. The spring force of the coil spring 18 is stored by the rotation of the gear 15. Then, the disk 17 is turned and the rotary shaft 3 is driven in the direction of normal rotation through the transmission shaft 16 and the driving gear 8 by the spring force stored in the coil spring 18. Because the rotational force is transmitted through the coil spring 18 in this manner, the rotational torque is smoothly transmitted to the disk 17, the driving gear 8, and the rotary shaft 3, even if the gear 15 is

intermittently rotated so as to cause stepping. Thus, the rotary decoration 5 can be driven smoothly in the direction of normal rotation.

As is explained in the foregoing description;

(1) The pulse intervals are set at small, equal intervals in a predetermined section in the middle section in the swing motion of the rotary decoration in one direction. Therefore, the rotary decoration is gradually accelerated in the direction of its normal rotation, and is driven at a constant speed in the middle section, and further is gradually decelerated after it passes this middle section. Accordingly, it becomes possible to impart an elegant and speedy motion to the rotary decoration.

And further, as there is no need for generating numerous pulses within a short period of time, it becomes possible to adequately increase the rotation cycle without decreasing the life of the battery. Furthermore, since the rotary decoration is driven to change its speed like a sine curve without using a conventional balance-wheel driving mechanism which requires a hairspring, it becomes possible to provide various goods (for example, a clock) adopting a rotary decoration at low cost.

(2) The pulse interval is set close in a predetermined

section immediately after the rotary decoration has changed its rotational direction. Namely, by outputting driving pulses in a short period of time by the amount required for loosening the wound coil spring and then re-winding it, it becomes possible to promptly wind up the coil. As a result, the rotary decoration is prevented from stopping at the time when the rotational direction of the rotary decoration is changed. Thus, an elegant swing motion can be imparted.

(3) The pulse is not outputted in a predetermined section immediately before the rotary decoration changes its rotational direction. That is, there is a no-pulse generating section provided immediately before the rotary decoration changes its rotational direction. Accordingly, just prior to when the rotary decoration reaches this no-pulse generating section, the wound up coil spring is gradually loosened to gradually impart the force accumulated in the coil spring to the decoration, and the rotary decoration continues to rotate by virtue of its inertia. Thus, it becomes possible to impart an elegant swing motion to the rotary decoration.



CLAIMS

1. A drive unit for a rotary decoration, which drive unit causes the rotary decoration to rotate alternately in a forward and a reverse direction in a substantially sinusoidal manner, having a stepping motor coupled to the rotary decoration through a damping circuit, a control circuit to control the movement of the stepping motor, and a memory circuit containing drive timing data relating to the time interval between successive movement steps of the stepping motor, wherein the control circuit controls the movement of the stepping motor in accordance with the drive timing data in the memory circuit, and wherein the drive timing data is such that the magnitude of said time intervals varies in a non-sinusoidal manner.
2. A drive unit for a rotary decoration as claimed in claim 1 wherein the drive timing data in each period of rotation of the rotary decoration, which period comprises a rotation in the forward direction or a rotation in the reverse direction, contains at least one sequence of successive time interval magnitudes which are substantially identical.
3. A drive unit for a rotary decoration as claimed in claim 2 wherein a sequence of successive identical magnitudes occurs for a rotary decoration position midway between consecutive reversals of the direction of rotation of the rotary decoration.
4. A drive unit for a rotary decoration as claimed in claim 2 or claim 3 where a sequence of successive small time interval magnitudes occurs immediately after a reversal of direction of the rotary decoration.
5. A drive unit for a rotary decoration as claimed in one of claims 2, 3 or 4 wherein the said time interval magnitudes during the or at least one of



the sequences substantially corresponds to the minimum pulse interval that can be applied to the stepping motor.

6. A drive unit for a rotary decoration as
5 claimed in any preceding claim wherein the last magnitude of said time interval prior to a reversal of the direction of the rotary decoration is considerably larger than the immediately preceding time interval.

7. A drive unit for a rotary decoration
10 comprising:

a stepping motor capable of rotating in both the normal and reverse directions for reciprocally driving a rotary decoration;

a memory circuit for storing the drive timing data
15 of said stepping motor; and

a control circuit for controlling said stepping motor on the basis of the data stored in said memory circuit;

said data being numeralized values of the pulse
20 intervals of operation pulses of said stepping motor so that the rotational speed of said rotary decoration can change like a sine curve; and

said pulse intervals in the middle section of the unidirectional rotation of said rotary decoration being
25 small and equal for a fixed section.

8. A drive unit for a rotary decoration
comprising:

a stepping motor capable of rotating in both the normal and reverse directions for reciprocally driving
30 a rotary decoration;

a memory circuit for storing the drive timing data of said stepping motor; and

a control circuit for controlling said stepping motor on the basis of the data stored in said memory
35 circuit;

said data being numeralized values of the pulse



-26-

intervals of the operation pulses of said stepping motor so that the rotational speed of said rotary decoration can change like a sine curve; and

5 said pulse intervals after switching the rotational direction of said rotary decoration being close for a fixed section.

9. A drive unit for a rotary decoration comprising:

10 a stepping motor capable of rotating in both the normal and reverse directions for reciprocally driving a rotary decoration;

a memory circuit for storing the drive timing data of said stepping motor; and

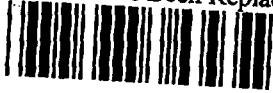
15 a control circuit for controlling said stepping motor on the basis of the data stored in said memory circuit;

20 said data being numeralized values of the pulse intervals of the operation pulses of said stepping motor so that the rotational speed of said rotary decoration can change like a sine curve; and

said data having a blank pulse portion for a fixed section before the rotational direction of said rotary decoration is switched.

25 10. A drive unit for a rotary decoration substantially as herein described with reference to Figures 3, 4, 8, 9 and 10 or to Figures 5, 8, 9 and 10, or to Figures 6, 7, 8, 9 and 10.

This Sheet Has Been Replaced



-27-

THIS SHEET HAS BEEN
REPLACED

Abstract

DRIVE UNIT FOR A ROTARY DECORATION

A proposed drive unit for a rotary decoration whose transmission gear train is configured to include a damper such as a coil spring, and which is capable of imparting a desired elegant swing motion to the rotary decoration.

There is a reciprocating stepping motor 9 capable of rotating in both the normal and reverse directions to drive a rotatory decoration 5 in such a manner that the rotatory decoration 5 causes a reciprocative swing motion. Also, a memory circuit 31 is provided for storing data for determining the drive timing of this stepping motor 9. Then, there is further provided a control circuit 32 for controlling this stepping motor 9 in accordance with the data stored in the memory circuit 31.

Said data numeralizes the pulse interval of the operation pulse for stepping motor 9 so as to transform the rotation speed of rotational decorating 5 as a sine curve, and

(1) the pulse intervals of operation pulses are set to uniform intervals having a small value in a predetermined section corresponding to an intermediate portion in one rotational direction of the rotary decoration 5, or

(2) the pulse intervals of operation pulses are set to close intervals in a predetermined section immediately after

THIS SHEET HAS BEEN
REPLACED

the rotational direction of the rotary decoration 5 is reversed, or

(3) the pulse intervals of operation pulses being set in a predetermined section immediately before the rotational direction of the rotary decoration 5 is reversed.

Fig. 3

This Sheet Has Been Replaced



FIG. 1

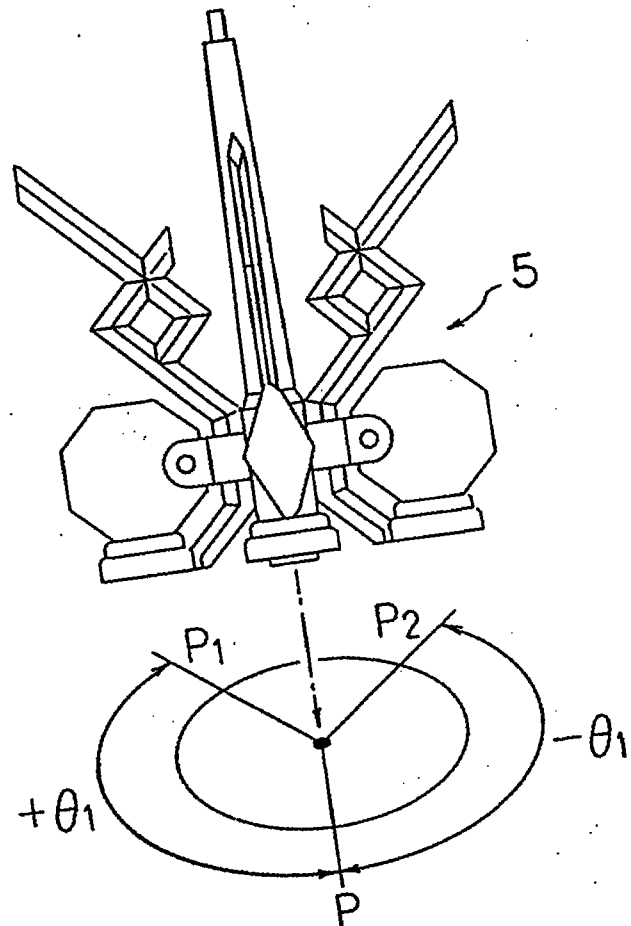


FIG. 2

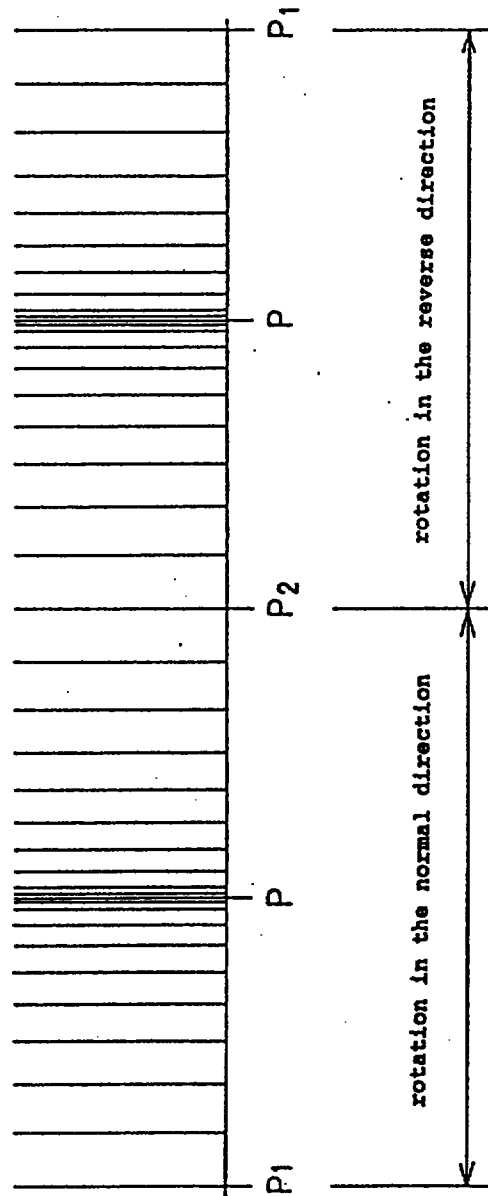


FIG. 3

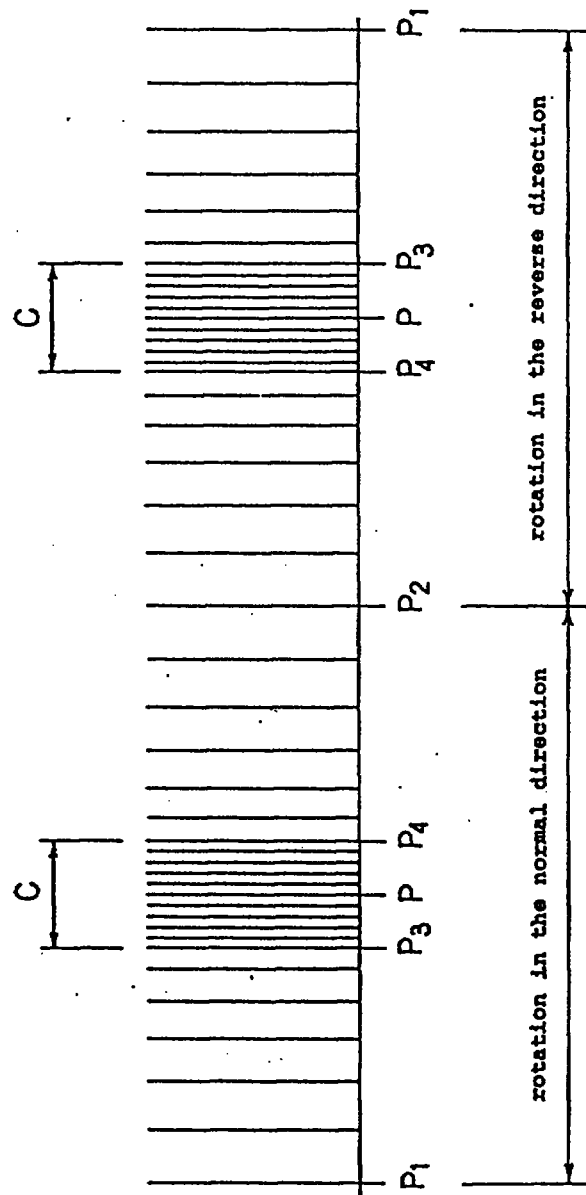


FIG. 4

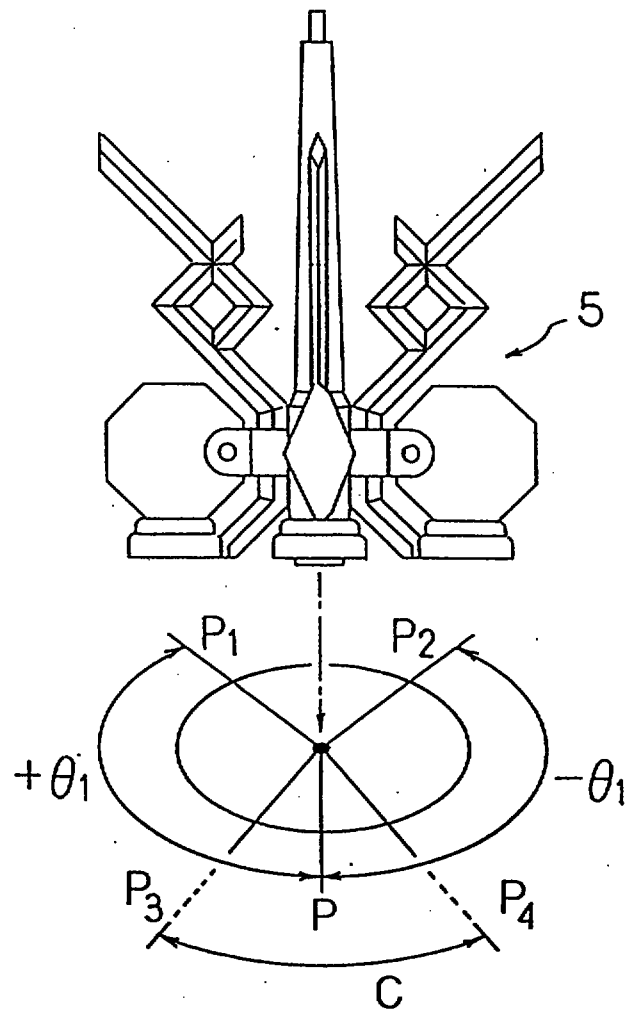


FIG. 5

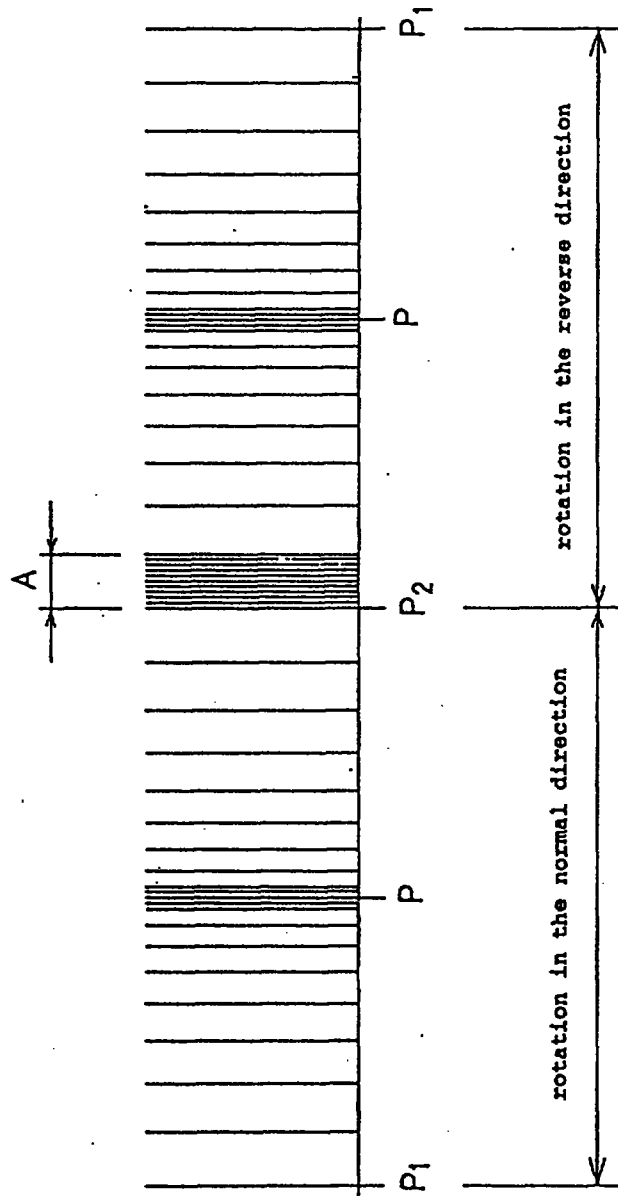


FIG. 6

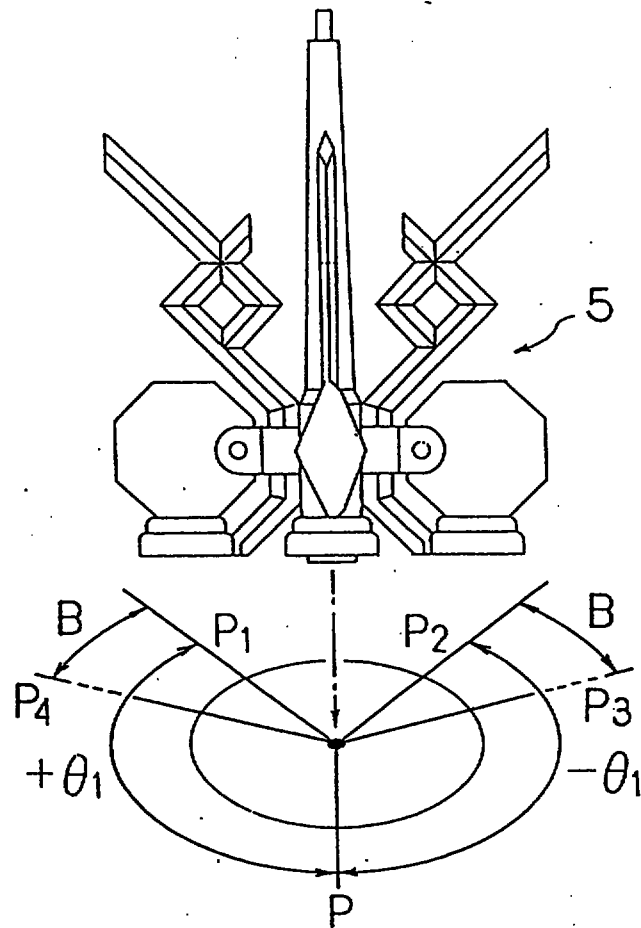


FIG. 7

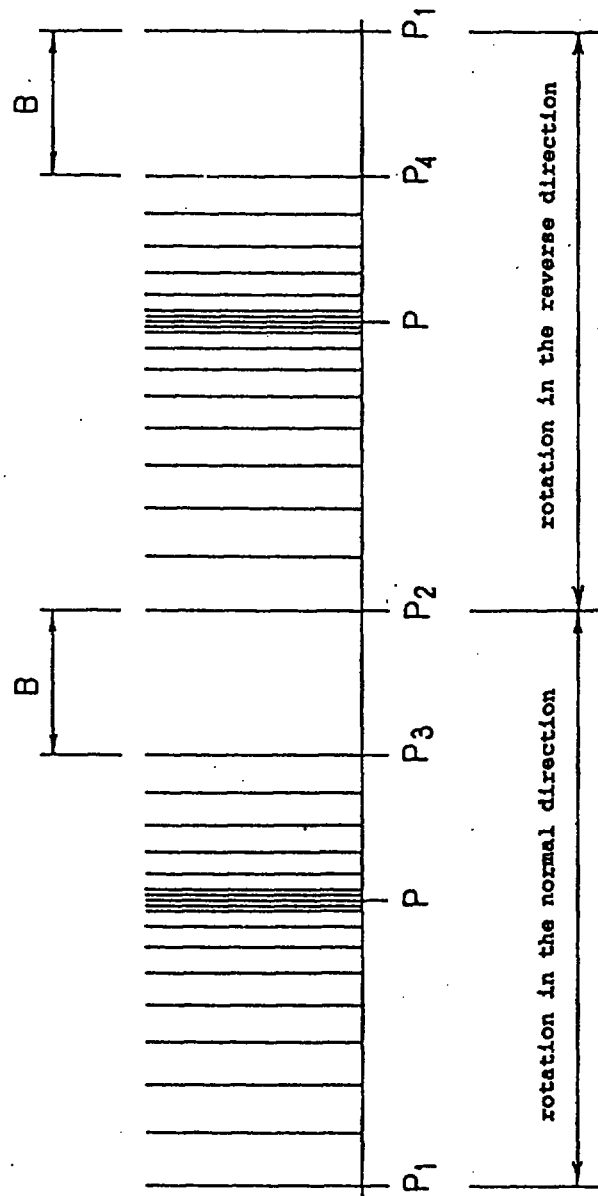
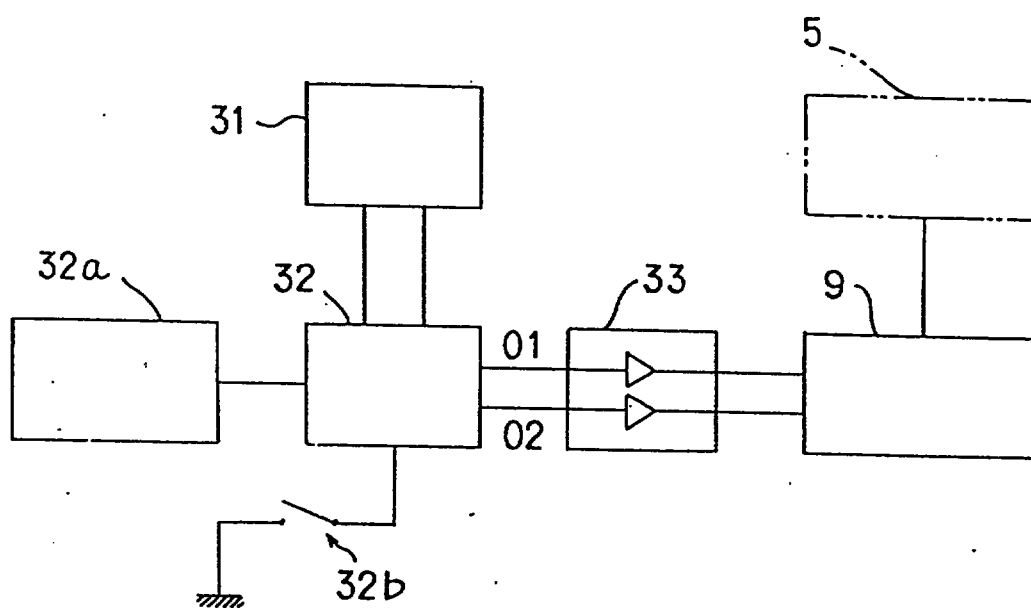


FIG. 8



F1 G.9

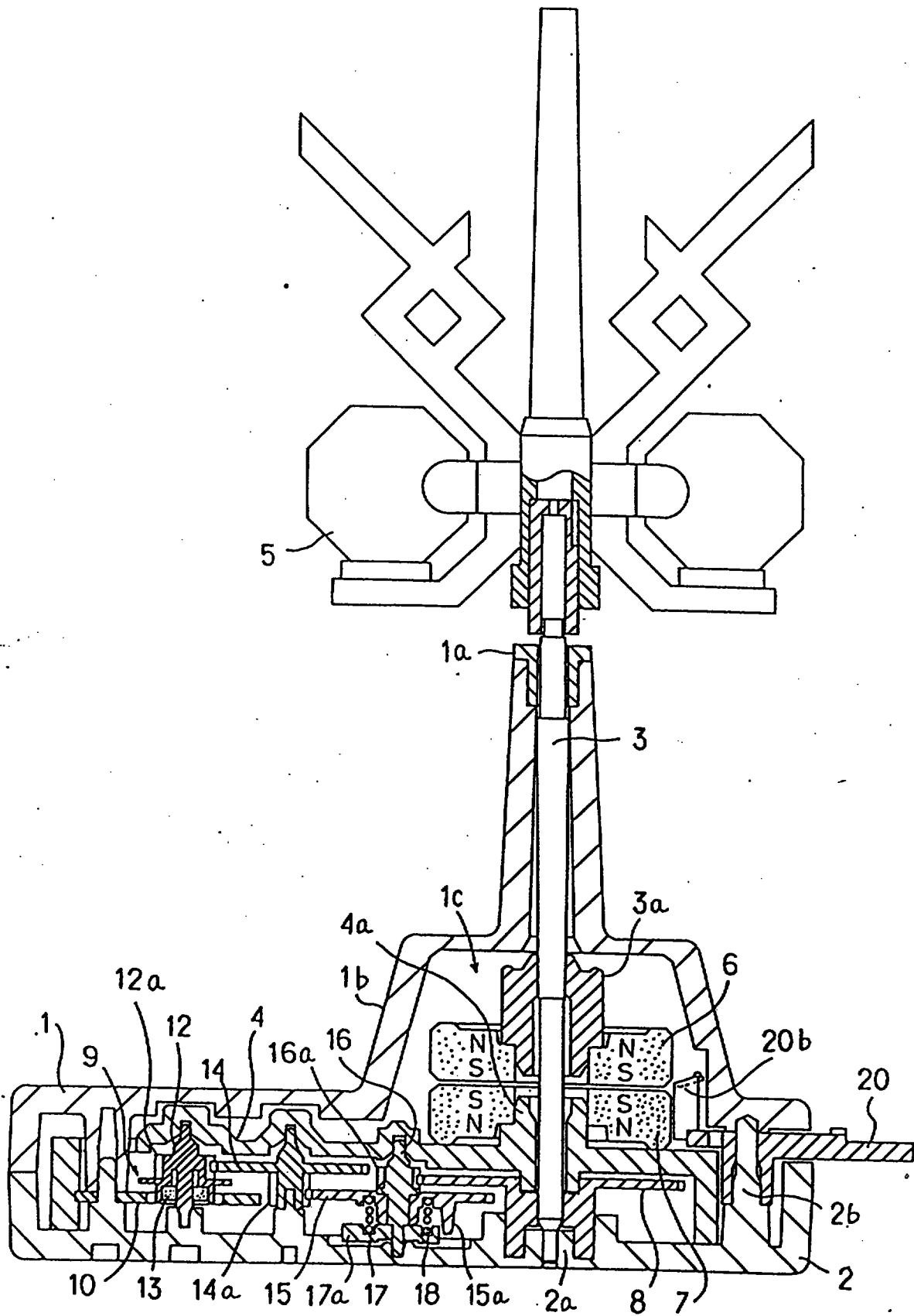
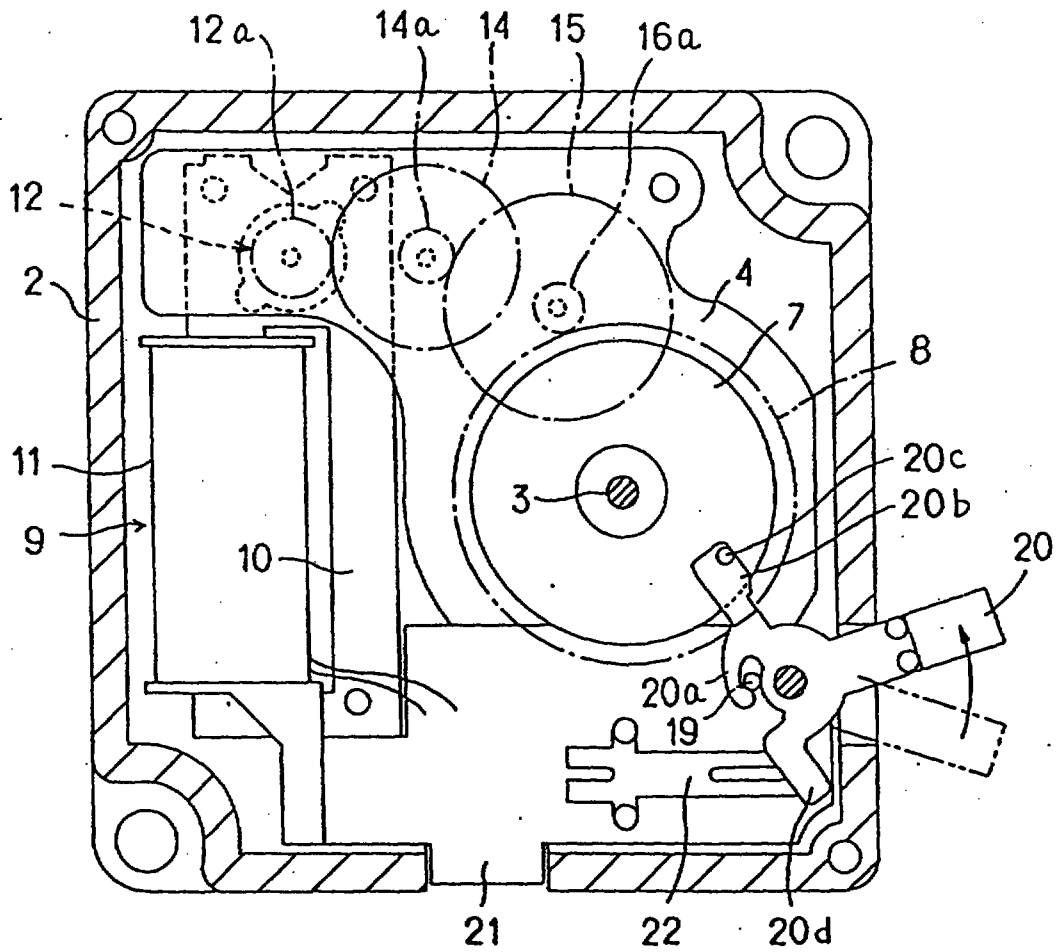


FIG. 10



- 27 -

DRIVE UNIT FOR A ROTARY DECORATION

ABSTRACT

A drive unit for a rotary decoration whose transmission gear train is configured to include a damper such as a coil spring, and which is capable of imparting a desired elegant swing motion to the rotary decoration.

The drive unit comprises a reciprocating stepping motor 9 rotatable in both the normal and reverse directions for driving a rotary decoration 5 in a reciprocative swing motion, a memory circuit 31 for storing data for determining the drive timing of the stepping motor 9, a control circuit 32 for controlling the stepping motor 9 in accordance with the data stored in the memory circuit 31.

The data numeralizes the pulse interval of the operation pulse for stepping motor 9 so as to transform the rotation speed of rotational decorating 5 as a sine curve, and the pulse intervals of operation pulses are

- (1) set to uniform intervals having a small value in a predetermined section corresponding to an intermediate portion in one rotational direction of the rotary decoration 5, or
- (2) set to close intervals in a predetermined section immediately after the rotational direction of the rotary decoration 5 is reversed, or

REPLACEMENT SHEET

02 AUG 1996

REPLACEMENT SHEETS SG

- ☐ Description : paged to paged
- ☐ Claim(s) : paged to paged
- ☐ Drawing(s) : paged to paged
- ☒ Abstract : paged 27 to paged 28.

DATE OF RECEIPT 2/8/96

(3) being set in a predetermined section immediately before the rotational direction of the rotary decoration 5 is reversed.

FIGURE 3

