(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 402 069 A2**

# (12) EUROPEAN PATENT APPLICATION

(21) Application number: **90306040.8**

(51) Int. Cl.[5]: **G04C 9/00**

(22) Date of filing: **05.06.90**

(30) Priority: **06.06.89 JP 143845/89**
**15.05.90 JP 124763/90**

(43) Date of publication of application:
**12.12.90 Bulletin 90/50**

(84) Designated Contracting States:
**CH DE FR GB LI**

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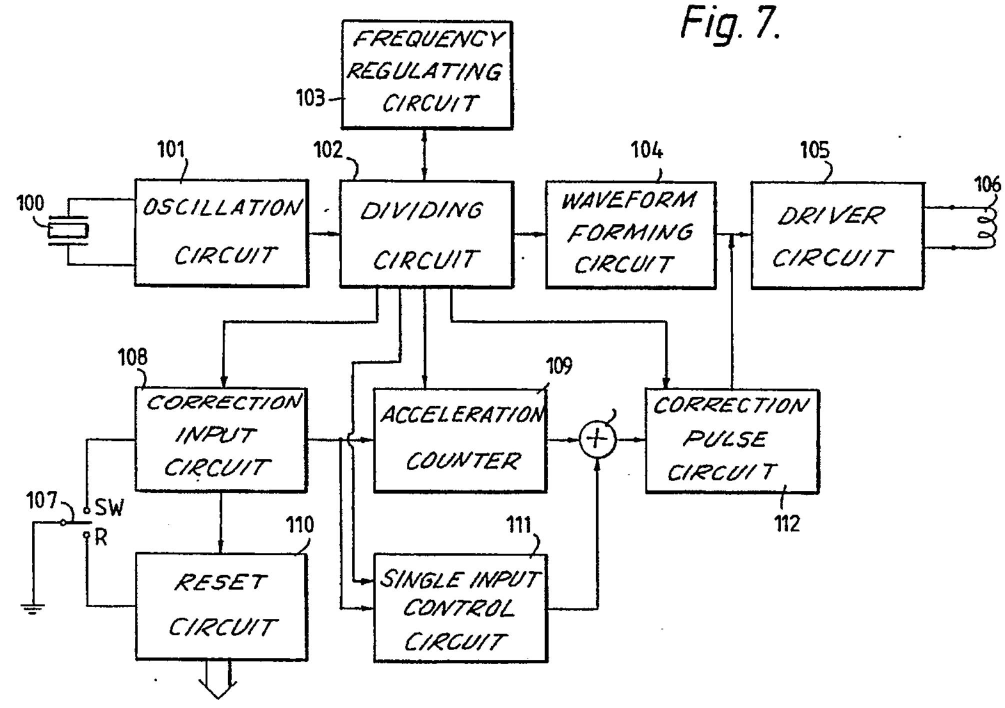
## (54) Electronic timepiece.

(57) An electronic timepiece has a stepping motor for driving a time display hand in response to an electronic signal generated by a crystal oscillator (100). A stem (27) of the timepiece is arranged to co-operate with circuitry (105) for driving the stepping motor such that the stepping motor is stopped when the stem is pulled out to a first position (b), and such that the stepping motor is advanced with a shorter cycle than usual when the stem is pulled out to a second position (c).

Fig. 7.




EP 0 402 069 A2

The present invention relates to an electronic timepiece.

Time correction in a conventional analog type of electronic watch has generally been carried out by engaging a gear train by pulling out a winder stem of the watch and by rotating the stem to turn the gear wheels of the gear train and thereby adjust the hands of the watch.

However, such a conventional arrangement has a number of disadvantages. In particular, when the stem is being rotated by hand during the time correction, it is also being subjected to a force from a stepping motor, which normally drives the watch hands, and this provides a large counter force. As a result of the opposing forces, the hands may suffer undesirable vertical movement and may strike one another when time correction is initiated. Further, when time correction is complete and the hands are re-started, the time indication may be altered as a result of back-lash, the hands being moved by the action of the stepping motor when the winder is pushed in in dependence upon the immediately preceding direction of hand adjustment. Consequently, it is difficult to obtain accurate time correction.

Further, both gear wheels for the time correction and a mechanism for engaging such gear wheels are required and it has been difficult to make the watch thin with so many members. In addition, in order to avoid the hands striking one another as far as possible, it has been necessary to provide a large space between the hour hand and the minute hand, between the minute hand and the watch glass, and between the hour hand and the face plate, and this also opposes a reduction in the thickness of the watch.

The present invention at least in its preferred form seeks to solve these problems and to provide an electronic timepiece, e.g. a watch, in which accurate time correction is possible and whose construction enables a reduction in the thickness of the timepiece to be realised.

According to the present invention, there is provided an electronic timepiece having a stepping motor, which is operable in response to an electronic signal generated by a crystal oscillator to drive a time keeping hand by way of a gear train, characterised in that a stem of the timepiece is arranged to co-operate with circuitry for driving the stepping motor such that, when the stem is pulled out, the stepping motor is driven to move the hand for correcting the time indicated by the hand.

The invention is described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a plan view showing parts of an electronic watch according to the present invention;

Figure 2 is a cross sectional view through a gear train of the electronic watch of Figure 1;

Figure 3 is a cross sectional view through a crystal oscillator of the electronic watch of Figure 1;

Figure 4 is a plan view showing details of a magnetic core and coil of the electronic watch of Figure 1;

Figure 5 (a) is a fragmentary side view of a portion of the magnetic core and coil shown in Figure 4;

Figure 5 (b) is a side view of a coil frame of the magnetic core and coil shown in Figure 4;

Figure 6 is a fragmentary view of parts of the electronic watch of Figure 1 showing their positions during time correction;

Figure 7 is a block diagram of the circuitry of the electronic watch of Figure 1;

Figure 8 is a circuit diagram showing details of a correction input circuit of the circuitry shown in Figure 6;

Figure 9 is a circuit diagram showing details of a single input control circuit of the circuitry shown in Figure 6; and

Figure 10 is a circuit diagram showing details of an acceleration counter of the circuitry shown in Figure 6.

The electronic watch shown in Figure 1 has a base plate 1 and a gear wheel location plate 2 supporting a gear train there-between. A circuit support plate 3 forms with the base plate 1 a space, which receives the circuit portion of the watch and a correction initiating mechanism.

A rotor 6 is provided with a rotor gear 6a and a rotor magnet 6b fixed by adhesion, and is arranged to be rotated by a magnetic attraction force applied when magnetic flux is generated by a coil 66 of a stepping motor of the electronic watch in a magnetic core 4 and a stator 5. The rotor 6 rotates a minutes gear wheel 9 through a gear wheel 7, provided with a wheel gear 7b and a gear stem 7a, and a gear wheel 8, provided with a wheel gear 8b and a gear stem 8a. The minutes gear wheel 9 is provided with a minute hand 36 for indicating the "minutes" and is rotatably mounted on a shaft 30 fixed to the wheel location plate 2. A gear stem 9a of the minutes gear wheel 9 rotates an hours gear wheel 11, carrying an hour hand 35, through a gear wheel 10. The reduction ratio from the minutes gear wheel 9 to the hours gear wheel 11 is set to be sixty whereby the hour hand 35 indicates the "hours". A face plate 31 and a watch glass 32 form a space for housing the hour hand 35 and the minute hand 36.

The gear wheel 10 is supported on a wheel shaft 34, and has a thickness determined by the face plate 31 and a convex portion 1c of the base plate 1. A hand location element 33 applies a spring force to the hours gear wheel 11 urging the wheel 11 away from the face plate 31 towards the gear wheel location plate 2. The hours gear wheel 11 thereby presses the minutes gear wheel 9 towards an end face 30a of the shaft 30. Consequently, the minutes gear wheel 9 and the hours gear wheel 11 can be located vertically relative to the end face 30 simply by adjusting the parallelism of the end face 30a and the face plate 31, even if a space exists between the minutes gear wheel 9 and the hours gear wheel 11. This inhibits undesirable vertical movement of the face plate and the hands relative to one another, which enables a reduction in the thickness of the watch to be realised. Further, the base plate 1 in this instance is cut out to receive the hours gear wheel 11, and so the thickness of the watch can also be decreased by an amount corresponding to the thickness of the base plate 1.

The crystal oscillator 12 having convex supports 3a and 3b provided on the circuit support plate 3 is connected to a circuit substrate 13 as described below. The circuit substrate 13 carries a CMOS IC 14, and an insulating spacer 17 serves to maintain the spacing between the circuit substrate 13 and both the location plate 2 and the circuit support plate 3. A re-set terminal pattern 15 and a correction terminal pattern 16 on the circuit substrate 13 are connected by lead portions 28 and 29 to the CMOS IC 14 on the circuit substrate 13. Terminals 18 and 19 are provided for connection to the negative and positive terminals, respectively, of a battery 20, the terminal 19 having convex portions 19a, 19b and 19c for locating the battery. Eccentric pins 25a and 25b serve for fixing the face plate 31 in place, and mounting screws 26, of which there are ten in the present example, are provided for the other parts.

The mounting of the crystal oscillator 12 is shown in Figure 3. The crystal oscillator 12 is elliptical and is fixed to the circuit substrate 13 by adhesive agent 60, being mounted on the side of its minor axis on inclined surfaces 1a and 1b of the base plate 1 so as to press against the convex supports 3a and 3b. The two dot chain lines 103 show the positions of the supports 3a and 3b when the crystal oscillator is not present, the supports being set to the lower position by bending or camber and being pressed upwardly when the crystal oscillator 12 is introduced. A stop 61 serves for preventing the adhesive agent from flowing outwardly. With this construction, the crystal oscillator is held firmly in place by the adhesive and the pressure of the supports 3a and 3b and the thickness of the watch can easily be reduced because of this simplified construction.

Figures 4 and 5 show details of the magnetic core 4 and the coil 66. A substrate 61 carries the coil lead patterns 62a and 62b for connection with the circuit substrate 13, the coil lead patterns 62a and 62b being fixed to terminal wires 64a and 64b of the coil 66 by solder 63a and 63b on the reverse side of the core 4. A coil frame 65a formed with an opening 65c is used as a guide during coil winding. An adhesive agent 61a fixes the coil lead substrate 61 to the core 4, the numeral 4a designating an inclined surface at the corner of the magnetic core 4 approaching the terminal wires 64a and 64b. A protective agent 67 covers the terminal wires. As shown in Figure 4 and Figures 5 (a) and 5 (b), the terminal wires 64a and 64b are arranged in the opening 65c of the coil frame 65a and are soldered to the coil lead patterns 62a and 62b. Accordingly, the terminal wires, being concealed within the coil frame and the protective agent, are hard to cut and do not affect the thickness of the watch.

The electronic watch further has a correction initiating mechanism including a winder 21 whose stem 27 is engaged with a setting lever 22 and is arranged when pulled out to cause the setting lever to act on a snap spring 23 and a re-set lever 24 as described below to initiate time correction. A rear portion of the re-set lever 24 selectively contacts the re-set terminal pattern 15 or the correction terminal pattern 16 according to the position of the stem 27.

Figure 6 is a fragmentary view showing the positions of the parts of the correction initiating mechanism during time correction. The full line a indicates the normal position of the winder and associated parts; the dashed line b indicates the positions of the parts in a first step of a time correction operation; and the double dashed line c indicates the positions of the parts in a second step of a time correction operation.

In the normal position, a ball portion 22i of the setting lever 22 is engaged within a groove 27i of the winder stem 27 fixed to the winder 21, a first tail portion 22k of the setting lever 22 is engaged with a zero step portion 24a of the re-set lever 24, and a second tail portion 22l is engaged with a zero step portion 23a of the snap spring 23. In this condition, a contact finger 24e of the lever 24 is in its position a and does not contact the terminal patterns 15 or 16. Consequently, the watch advances as usual.

When the winder 21 is pulled out to the first position b, the setting lever 22 rotates around a pivot 53. As a result, its first tail portion 22k releases the step portion 24a of the re-set lever 24, and the re-set lever 24 is urged by the engagement of a spring finger 24d thereof with a stop 51 to move the contact finger 24e to its position b in contact with the re-set terminal pattern 15. The second tail portion 22l of the setting lever 22 engages a first step portion 23b of the snap spring 23 after passing over a first crest 23a′ of the spring. The snap spring 23 is resiliently biased into this position by the engagement of a spring finger 23d thereof with a stop 52, which urges the spring to rotate around a pivot 54.

When the winder is pulled out to the second position c, the contact finger 24e moves to its position c, in which it contacts the correction terminal pattern 16, as a result of the first tail portion 22k of the setting lever moving to engage and lift a further step portion 24c of the re-set lever 24 counter to the force exerted by the deflection of the spring finger 24e. The second tail portion 22l of the setting lever 22 engages a second step portion 23c of the snap spring 23 after passing over a second crest 23b′.

With such a construction, the parts are held in the first position b, and are returned automatically from the second position c to the first position b when the winder 27 is released, by the returning force of the spring finger 24d of the re-set lever 24 and the spring finger 23d of the snap spring 23.

The circuit portion of the electronic watch of the present invention will now be described with reference to Figures 7 to 10. The waveform generated in the crystal oscillator 100 (corresponding to the crystal oscillator 12 shown in Figure 1) and an oscillation circuit 101 is divided in a dividing circuit 102 according to a rate set by a frequency regulating circuit 103. A suitable pulse form is produced in a wave shaping circuit 104, and the coil 106 (corresponding to the coil 66 in Figure 1) of the stepping motor is magnetised through a driver circuit 105. When a switch 107 (corresponding to the re-set lever 24 in Figure 1) is switched to a terminal R (corresponding to the re-set terminal pattern 15 in Figure 1), all the various circuits are re-set through a re-set circuit 110. When the switch 107 is switched intermittently to a terminal SW (corresponding to the correction terminal pattern 16 in Figure 1), a correction pulse is generated in a correction pulse circuit 112 by way of a correction input circuit 108 and a single pulse input control circuit 111. This correction pulse is applied to the driver circuit 105 in order to magnetise the coil 106 and drive the stepping motor with a shorter cycle than is usual during normal time display. The number of pulses need not be limited to one. If the switch 107 is continuously positioned at the SW terminal, there is a pause for a certain period of time after an initial correction pulse is output, and then a further pulse is output from the correction pulse circuit 112 by way of an acceleration counter 109. Each further pulse is standardised by the acceleration counter 109 by the waveform produced by the dividing circuit 102, and is changed slowly to have a shorter cycle in proportion to the length of time that the switch 107 is positioned at the SW terminal. Therefore, the time displayed by the watch can be corrected slowly by operating the switch 107 intermittently, or it can be corrected quickly by operating the switch 107 continuously.

Figure 8 is a circuit diagram showing details of the correction input circuit 108. When the switch 107 is positioned at the SW terminal, the level of a switch signal SW becomes high through an inverter 120 and a chatter preventing circuit 115. A switch continue signal Scnt delayed by a time d following the transition of the switch signal SW to the high level is also generated by means of a delay circuit 113. The delay circuit 113 has a flip flop 121 and a D latch 122, and the switch continue signal Scnt is derived from both a clock signal $\phi$ output by the dividing circuit 102 and the switch signal SW by means of these parts.

Figure 9 is a circuit diagram showing details of the single pulse input control circuit 111. The single pulse input control circuit generates a driving signal Ps by applying to an AND gate 125 a clock signal $\phi s$, and a differential waveform Sd derived from the switch signal SW and a clock signal $\phi d$ by means of a differential circuit 114 comprising a flip flop 123 and a D latch 124. Both the clock signals $\phi s$ and $\phi d$ are supplied by the dividing circuit 102. At this moment, the pulse width of the waveform Sd is less than that of the switch signal SW, and the cycle of the clock signal $\phi s$ is shorter than that of the waveform Sd.

Therefore, in the circuits shown in Figure 8 and Figure 9, when the switch 107 is positioned at the SW terminal, the driving signal Ps is initially output (a pair of pulses are shown in Figure 9), and then, after a certain period of time, the switch continue signal Scnt becomes high. If the time in which the switch 107 remains positioned at the SW terminal is shorter than d, the switch continue signal Scnt remains at a low level without changing.

Figure 10 is a circuit diagram showing details of the acceleration counter 109. Differential circuits 116, 117 and 118 generated differential waveforms a, b and c, respectively, in response to the switch continue signal Scnt and in response to clock signals $\phi d_1$, $\phi d_2$ and $\phi d_3$ from the dividing circuit 102. The pulse width is c > b > a as shown. The waveforms a, b and c are applied directly and by way of inverters 129, 130 to AND gates 126, 127 and 128 as shown, together with motor fast forward signals $\phi_1$, $\phi_2$ and $\phi_3$, which latter are supplied by the dividing circuit 102 and are output as a fast forward signal Pcnt in the order $\phi_1$, $\phi_2$ and $\phi_3$ through an OR gate 131. The fast forward signal Pcnt and the driving signal Ps are both applied to an OR gate 132 for supplying a motor acceleration signal Pac.

Now, if the cycle of the motor fast forward signals is $\phi_1 > \phi_2 > \phi_3$, the cycle of the fast forward signal Pcnt becomes slowly shorter. Further, if the pulse width of the differential waveforms is set, for example, such that a > b-a > c-b, the change from a longer cycle to a shorter cycle becomes faster.

The correction pulse circuit 112 includes differential circuits arranged to set the motor acceleration signal Pac to have a minimum pulse width, whereby an energy saving function may be realised.

The re-set circuit 110 includes a chatter-preventing circuit, and means for re-setting the whole of the circuitry, for example a flip flop and a latch.

The oscillation circuit 101, the dividing circuit 102, the frequency regulating circuit 103, the wave shaping circuit 104 and the driver circuit 105 may be similar to circuits provided in a conventional electronic watch. The output from the dividing circuit 102 is suitable for providing the various clock signals described above.

Various modifications are possible in the described circuitry. For example, the above mentioned delay circuit 113 and differential circuit 114 may be replaced by alternative structures. Also, the number of switching steps for the fast forward signal Pcnt in the acceleration counter 109 is not limited to three.

As described above, the arrangement for time correction in the present invention in which the stem 27 is pulled out from the zero position a to the first position b, and from the first position b to the second position c, promotes accurate time correction in a simple manner without error and the need for error adjustment. When the stem 27 is pulled out for a short period of time, the time correction is carried out by advancing the hands slowly and, when it is pulled out for a long period of time, the time correction is carried out by performing the fast forward stepping motor action with acceleration. Therefore, a time correction operation, which is both easy and quick, can be obtained.

Further, the present invention enables the thickness of an electronic watch to be reduced, by employing the base plate 1 having the cut out portion for the shaft 30 of the minutes gear wheel 9, by pressing the hours gear wheel 11 and the minutes gear wheel 9 towards the base plate 1 by means of the location element 33, by utilising an arrangement for correcting the time involving fast forward rotation of the stepping motor, by fixing the elliptical crystal oscillator 12 by pressure from the circuit support plate 3 and by arranging the terminal wires 64a and 64b of the coil 66 in the space of the coil frame 65a.

Consequently, the present invention offers a number of significant advantages as described.

## Claims

1. An electronic timepiece having a stepping motor, which is operable in response to an electronic signal generated by a crystal oscillator (12) to drive a time keeping hand (35, 36) by way of a gear train (7 to 10), characterised in that a stem (27) of the timepiece is arranged to co-operate with circuitry (105) for driving the stepping motor such that, when the stem is pulled out, the stepping motor is driven to move the hand for correcting the time indicated by the hand.

2. A timepiece according to claim 1 characterised in that the stem has a normal position, in which it is pushed in, and first and second positions, in which it is pulled out, and in that, in the first position, the stem is arranged to co-operate with circuit resetting means (15, 110) whereby to stop the stepping motor and, in the second position, the stem is arranged to co-operate with correction means (16, 108 to 112) whereby to advance the stepping motor with a shorter cycle than usual for correcting the time indicated by the hand.

3. A timepiece according to claim 2 characterised in that the correction means are arranged to drive the stepping motor in a first mode, which is a relatively slow mode, when the stem is intermittently pulled out to the second position and in a second mode, which is a fast forward mode, when the stem is held continuously in the second position.

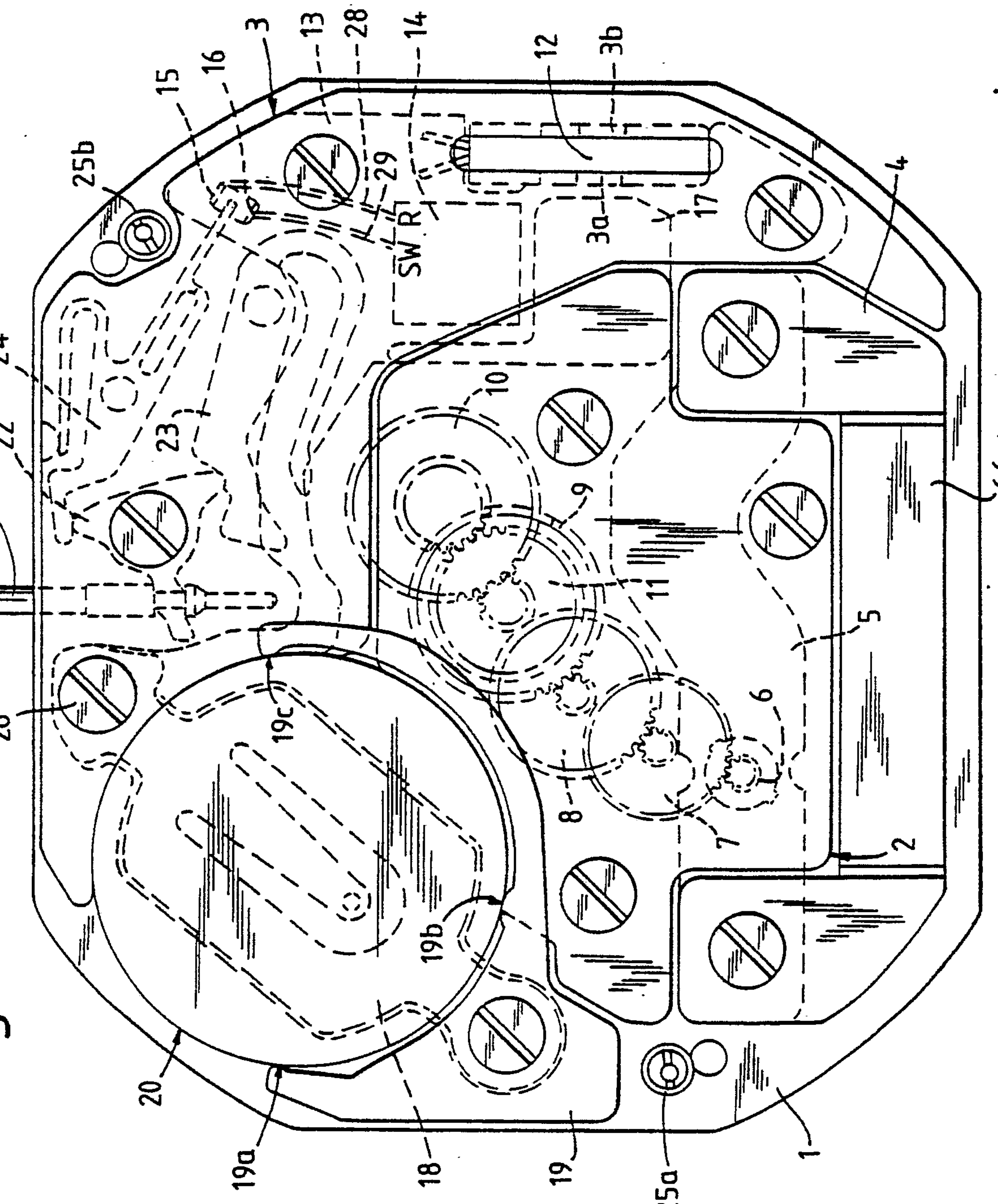
4. A watch according to claim 3 characterised in that, in the second mode, the correction means are arranged to generate a fast forward pulse signal, whose cycle becomes increasingly short, for driving the stepping motor.

5. A time piece according to any preceding claim characterised in that the stem is arranged when pulled out to operate a correction initiating mechanism (22 to 24) for actuating a switch (15, 16, 24e) for effecting time correction.

6. A timepiece according to any of claims 2 to 4 characterised in that, in the second position, the stem is biased towards the first position.

7. A timepiece according to any preceding claim comprising a watch.

8. An electronic timepiece for driving a stepping motor and for driving an indication hand (35, 36) through a gear train (7 to 11) by an electronic signal generated in a crystal oscillator (12) and a CMOS IC (14), characterised in that the stepping motor is stopped by pulling out a stem (27) from a usual position (a) to a first position (b), and in that the stepping motor is advanced with a shorter cycle than usual by pulling out the stem to a second position (c).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2
3
3a
3b
4
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10
11
12
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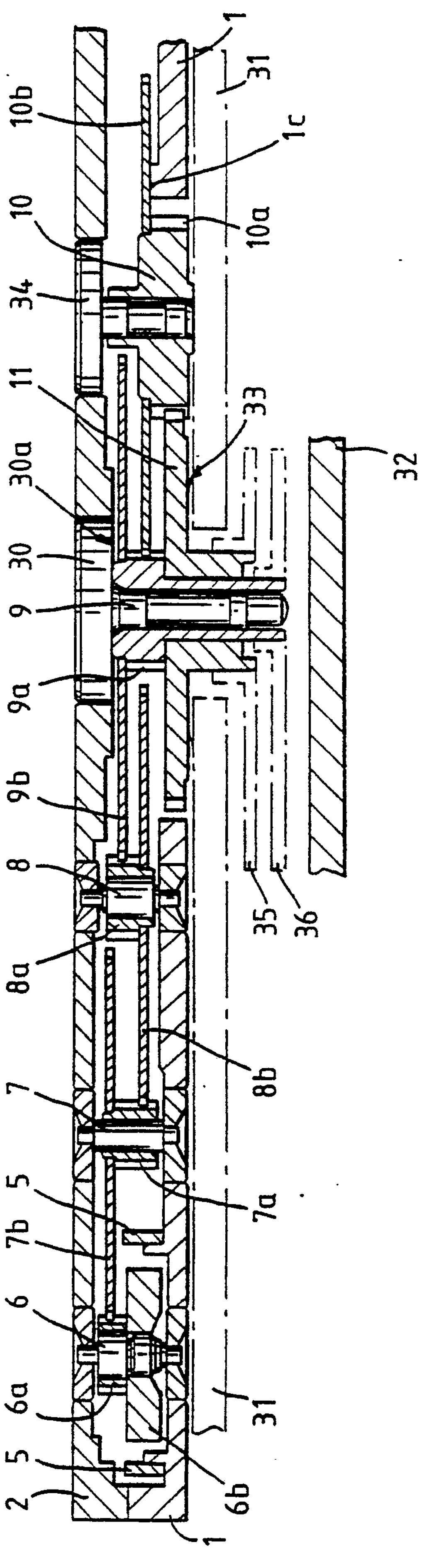
16
17
18
19
19a
19b
19c
20
21
22
23
24
25a
25b
26
27
28
29
66
SW R

Fig.1.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7b
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6a
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Fig.2.

Fig. 3.

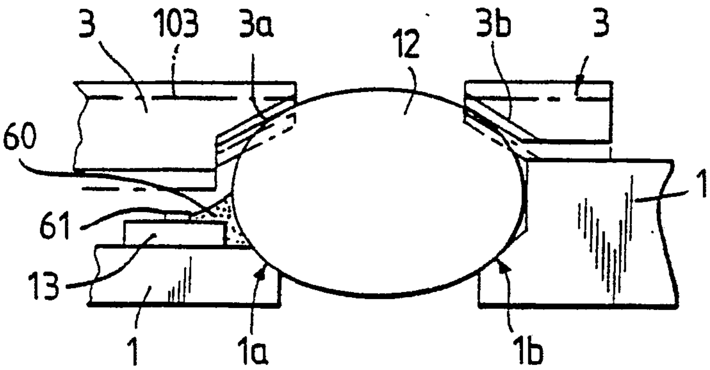



Fig. 4.

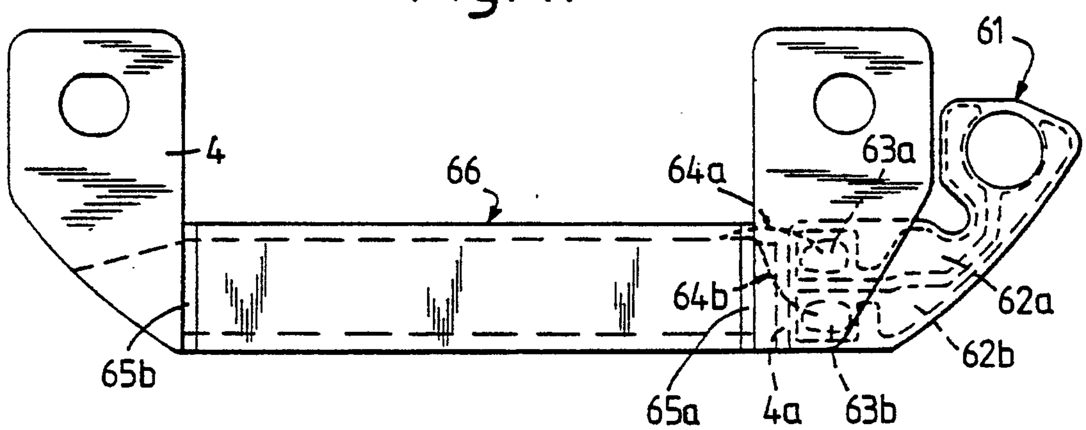



Fig. 5(a)

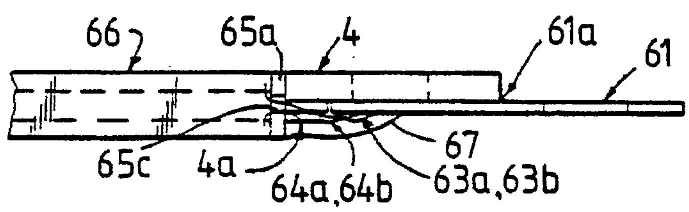
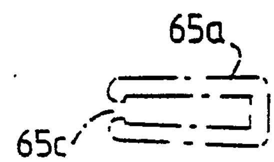
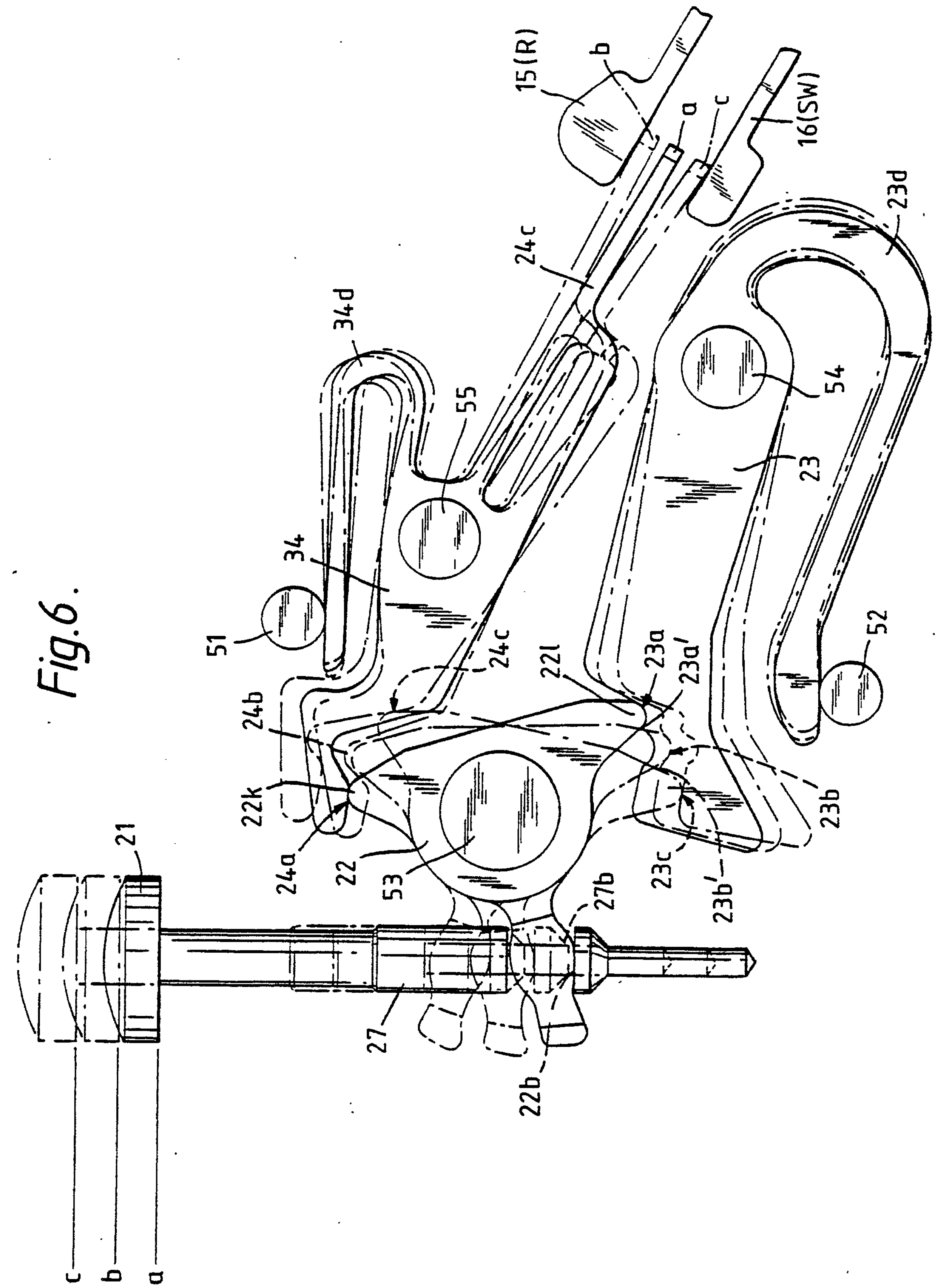



Fig. 5(b)

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b
a
c
16(SW)
23d
24c
34d
55
54
23
34
51
52
24c
22l
23a
23a'
24b
22k
24a
22
53
23b
23c
23b'
21
27b
27
22b
c
b
a

Fig.6.

Fig. 7.

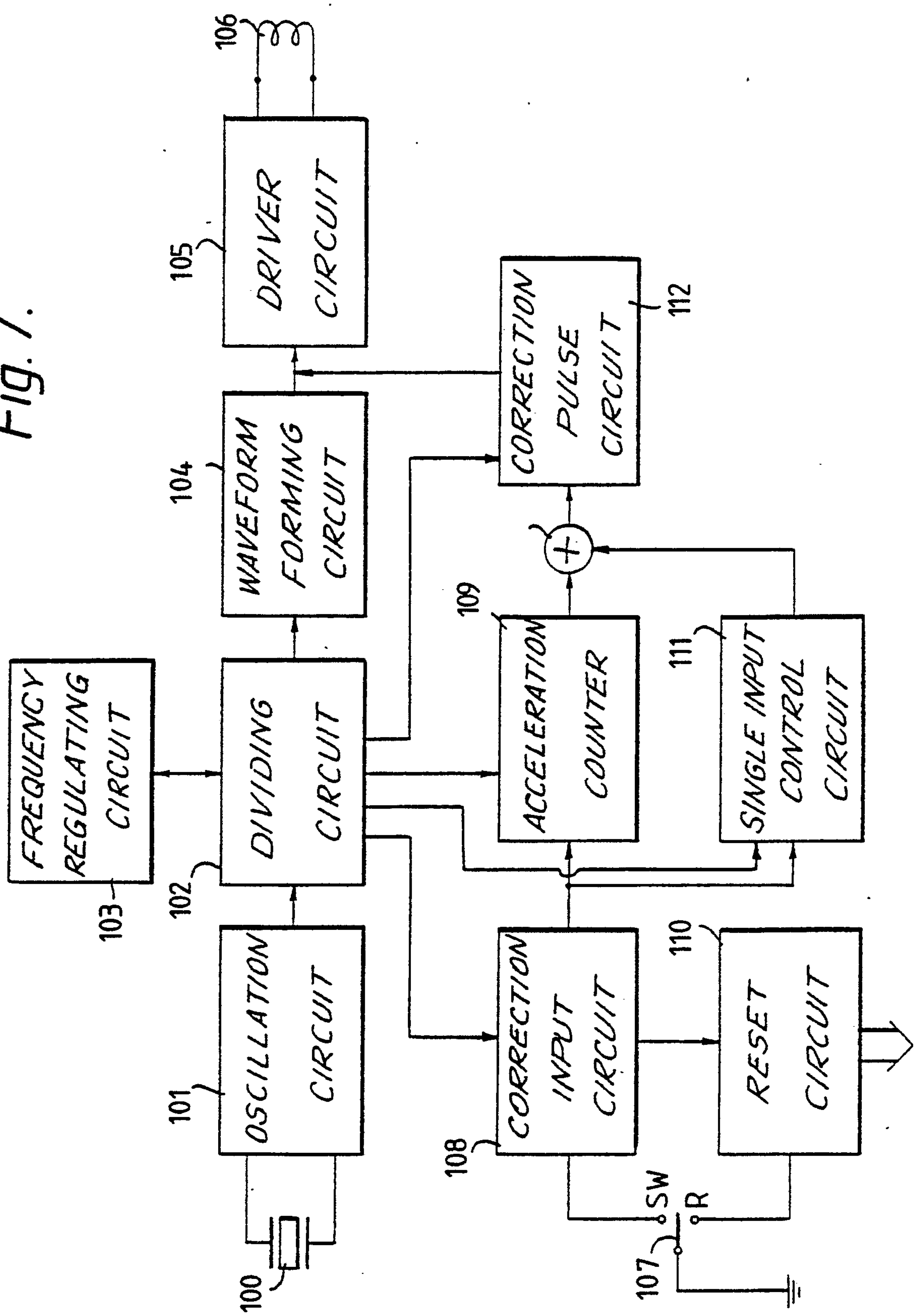
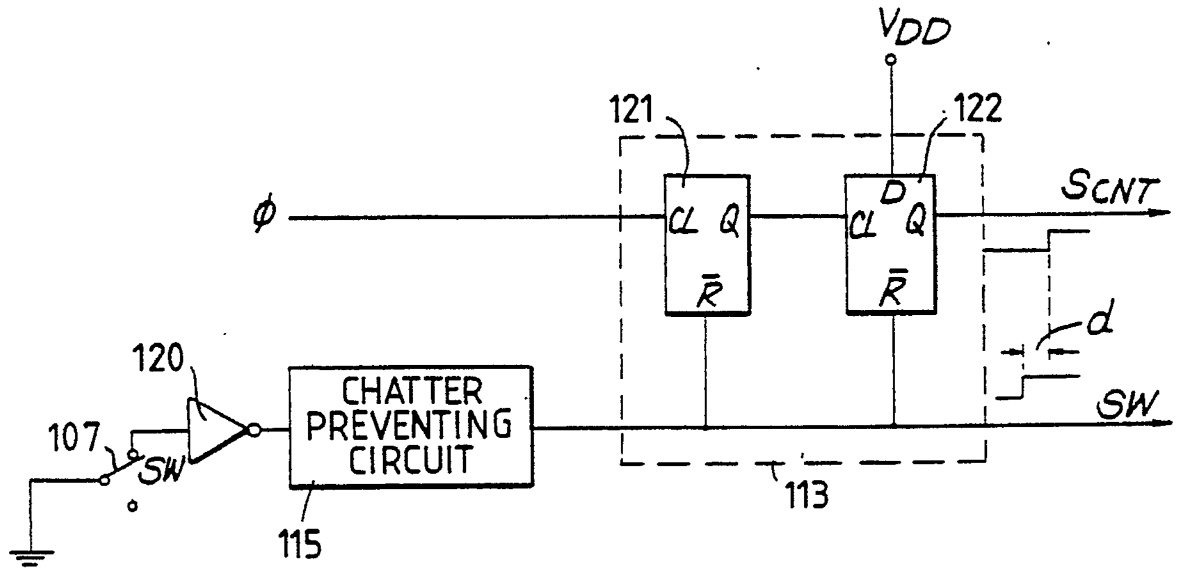

100
101
OSCILLATION CIRCUIT
102
DIVIDING CIRCUIT
103
FREQUENCY REGULATING CIRCUIT
104
WAVEFORM FORMING CIRCUIT
105
DRIVER CIRCUIT
106
107
SW
R
108
CORRECTION INPUT CIRCUIT
109
ACCELERATION COUNTER
110
RESET CIRCUIT
111
SINGLE INPUT CONTROL CIRCUIT
112
CORRECTION PULSE CIRCUIT

Fig. 8.


VDD
121
122
φ
CL Q
CL D Q
R̄
R̄
SCNT
d
120
CHATTER PREVENTING CIRCUIT
SW
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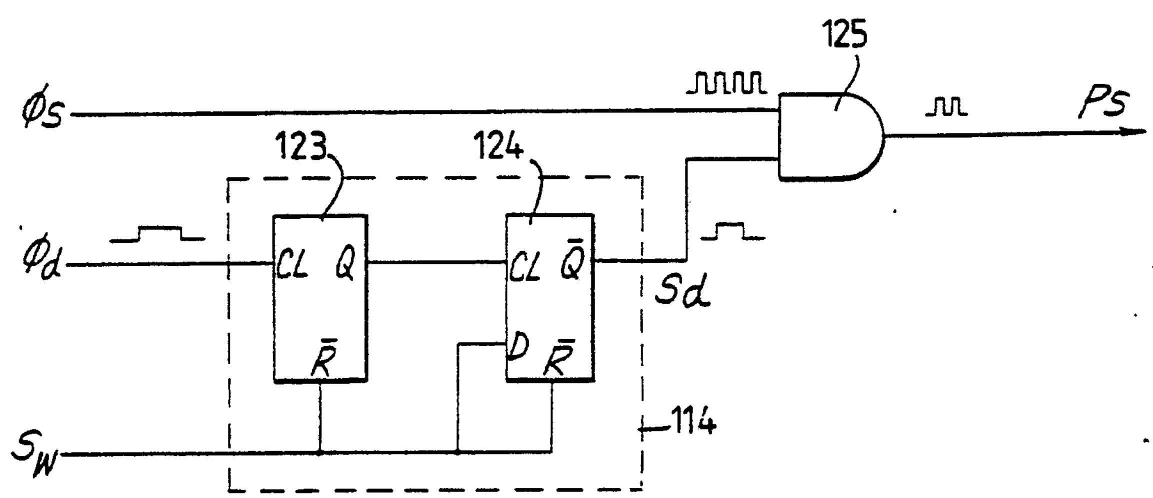
SW
115
113

Fig. 9.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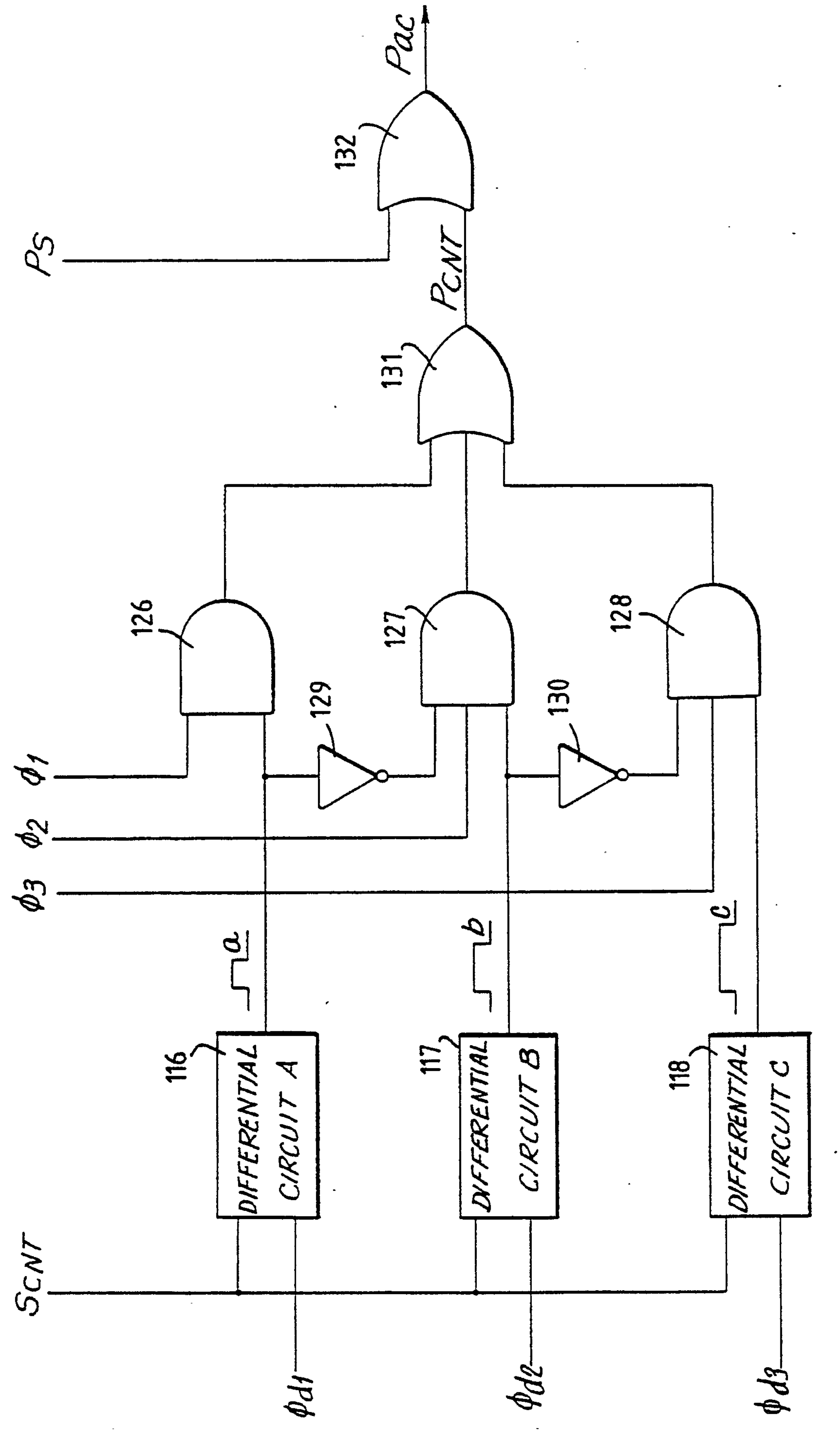
φd
CL Q
CL Q̄
Sd
R̄
D R̄
114
SW

Fig. 10.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126
127
128
129
130
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$\phi_2$
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a
b
c
116
DIFFERENTIAL CIRCUIT A
117
DIFFERENTIAL CIRCUIT B
118
DIFFERENTIAL CIRCUIT C
$S_{CNT}$
$\phi_{d1}$
$\phi_{d2}$
$\phi_{d3}$