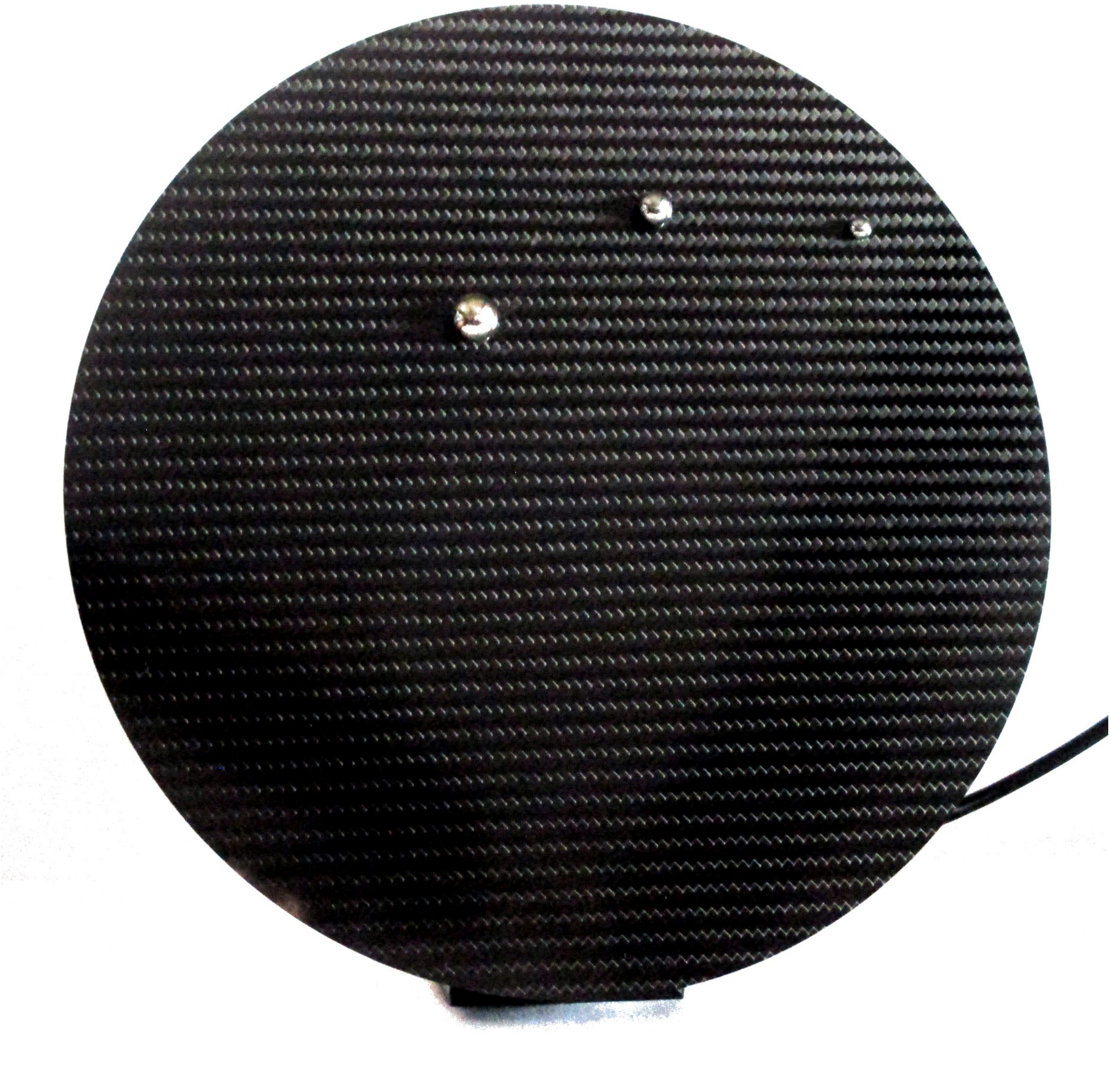
The Ball Clock



December 2022

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Instruction Manual

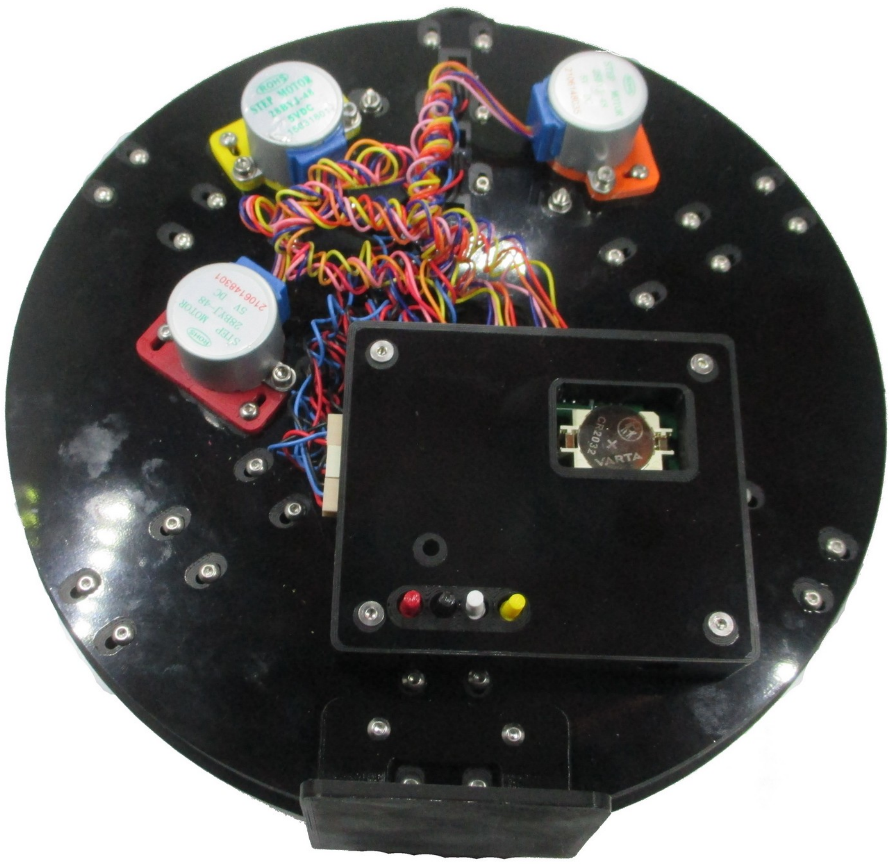
Principle

The Ball Clock is the maximum abstraction of a clock pointer. The time is displayed via steel balls that seem to move weightlessly over a carbon plate. The hands are not fixed centrally as usual with a mechanical clock. There is no clock-face.

The time must be estimated from the position of the balls. The resulting inaccuracy of the display is due to the design and is expressly intended to be so.

Pic. 1: The inner workings of the Ball Clock

The balls are held and guided on the carbon plate by means of small neodymium magnets. The balls are moved by three invisible gear rings on the opposite side of the cover plate. These are driven via gears by stepper motors. The steppers are driven and controlled by electronics around an Atmel Mega 328P microcontroller. He takes over all control tasks. To ensure that the time is always displayed correctly, the processor has a battery-buffered real-time clock (Dallas DS 1307) at its disposal. As a result, the internal clock continues to run with quartz precision even in the event of a power failure. In that case the balls have to be reinitialized in order to display the time correct again.



Pic. 2 Backside View

Operation

The clock is powered by a plug-in power supply unit with 12 V / 500 mA DC voltage. The connection is on the button side of the electronics case (2.1 mm jack plug). All adjustment are done via four buttons on the backside. The keys have different meanings depending on whether they are pressed shortly or long. "Long press" means approx. 1 second.

Meaning of the keys:

RED Button: Hours

- short press: Adjust clock one hour ahead
- long press: Set clock one hour back

BLACK Button: Minutes

- short press: Adjust clock one minute ahead
- long press: Set clock one minute back

WHITE Button: Initialisation and calibration

- short press: starts initialisation
  During intialisation the balls move to the 12.00 position and stop.

- again short press: restarts the clock after initialisation and the balls move to show the current time

- long press: starts calibration of the clock. The balls move to the sensors and than another round to determine the number of steps for one full revolution. The resulting values are stored inside the clocks EEPROM.

YELLOW Button: Switch seconds ON and OFF and stops clocks displaying time

- short press: Moves the seconds ball to 12.00 position and stops displaying seconds (Ball parking position). You can remove the ball now. Hour and Minute are not affected.

- again short press: Restart seconds display
  The seconds ball moves to the actual seconds position and moves again as the seconds progress.

- long press: Switch Clock display OFF (only the ball movements stop, the internal real time clock continues to run

- again long press: Switch the clock ON again (if switched off before)

Pic. 3 Pushbuttons

Start-up

After connecting the power supply, the clock must be started. To do this, short press the white button. The watch initializes itself automatically. The balls move to the 12 o'clock position. If no balls have been placed yet, you can do so now. Find the balls position at 12 o'clock.

After that short press the white button again: the balls move now to the current time and the clock starts running.

Setting the Time

The red and **black** buttons are used to set the time.

Short press the red button to put the clock one hour forward.

Long press the red button to set the clock one hour back.

Short press the **black** button to increase the minute by one minute.

Long press the **black** button to go back one minute.

The adjusted time is saved inside the clocks RTC chip and persists even after disconnection from the power supply.

Initialisation

To initialize the clock short press the white button.

During initialization, the steel balls move to the 12:00 position and remain there. This is useful if they need to be taken off, e.g. if you want to clean the front panel. So you know where the magnet positions are and you can dock the balls again without searching the positions. A short press of the white button starts the clock again.

The clock initializes itself twice a day without the user having to do anything. Automatic initialization can be defined in the arduino sketch. By default it starts at just before 6:00 a.m. and just before 6:00 p.m.

Calibration

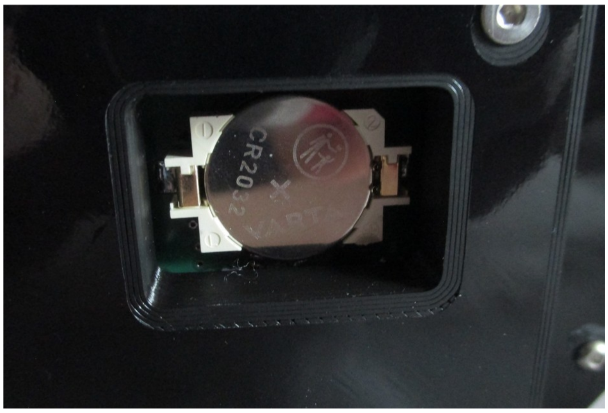
In order to display the correct time, the clock needs data on how many steps the stepper motors have to take to complete a full revolution. This may require calibration from time to time.

If the clock shows the wrong time after a while, a recalibration can be helpful. To achieve that, proceed as follows:

Long press the white button. The calibration starts automatically. First, the balls move forward one after the other to the built-in Hall sensor (at approx. 12:00 o'clock). Then they perform another complete full revolution again and counts the necessary steps. The result is saved in the clocks EEPROM. This completes the calibration.

Battery Change

The real-time clock requires a 3V lithium button cell (CR2032) as a backup battery to maintain the time signal.



Pic. 4 : Battery CR2032

The service life of this battery is estimated at around 3 years.

If the clock goes wrong again after a while or if it loses the correct time after disconnecting the supply voltage, the buffer battery must be replaced.

To do this, use a small screwdriver to loosen the battery on the MINUS side and press upwards. There is no need to remove the cover doing this.

In December 2022

Marie & Stefan Kneip