

# **THE MILLENNIUM TIME PROJECT: ALTERNATIVE TIME MEASURING MECHANISMS**



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# **1. PREFACE**

## **1.1. Introduction**

In the remote past from the embryo of human civilisation people needed means to measure time and tried various devices making many attempts to create such means. The conditions available then and the low level of social development and its habitual level of knowledge of nature and exact sciences made it almost impossible to create satisfactory methods and devices. Initially, people used several most easily available means such as the Sun, the Moon and seasonal peculiarities as for example the snow in order to measure time in periods – days, months, seasons and years [1].

One of the first devices used to measure the hours in the day was the sundial which measured time relative to the shade cast by a vertically position bar in a flat sunny location. Moreover, the shade moved along an oval-elliptical curve and had a specified length for independent hours depending on the time and season. Later and perhaps parallel to the progress in engineering and trade the sand glass was created [1]. This is a device where a loose material, sand for example, is being poured from a container having a specified volume into another similar container and this is usually completed within a certain period of time. This device samples of which are still kept as antiques was later substituted by the mechanical clocks and devices for measuring time that emerged as a result of the progress in exact sciences like mathematics and physics and initially based on the physical and simple pendulum and its most important for the application scientifically established property:  $T = 2\pi\sqrt{l/g}$  [1].

During oscillation the time T for one pendulous movement at average deviation amplitudes is a constant value, which does not depend on the speed and amplitude of oscillation but only on the length of the arm of the pendulum. This was the solution to the first historically task from system dynamics. An important element from the clock mechanism was thus created and established that was also used for any other device for measuring time or certain parts of time, from 1 sec to 24 hours in a day or more [1]. Gradually developing was the driving technique and mechanism. Weight clocks were also spreading. The driving force in them is the potential energy of a weight mounted at a certain height, which under the action of gravity can turn into kinematical energy and induce mechanical movement into the mechanism driving the time indicating hands on scales and dials of various shapes and constructions. Gradually, other potential energy sources and driving mechanisms were adopted like tensioned spring either spiral or linear [1]. Various electrical current motor driving means were later adopted and recently, such based on solar or atomic power and living nature temperature and energy are being used such as the automatic self-winding clock mechanisms and clocks with solar or heat batteries.

One major problem has always stood in front of design engineers when considering existing time measuring devices and this is the necessity for movement uniformity of the mechanism. The intervals being indicated should have the lowest possible difference from the exact time. From all existing clocks the one that is most satisfactorily meeting this demand is the pendulum with an arm driven by means of an anchor and anchor wheel but due to the substantial dimensions of such a regulator this has almost been substituted by a regulating mechanism, which also uses a pendulum with an anchor mechanism but has the shape of a

flywheel with a spiral spring. This is widely used type of regulator and provides high precision of movement and time measurement [1].

Modern society has created and made available a number of various time measuring devices and mechanisms starting with the ordinary clocks indicating the hour, minutes and seconds in the day, the day from the week, the date, year and time differences along the globe meridians and longitudes and end up in the most accurate devices for measuring processes and time with an accuracy of micro- or nano-seconds in nuclear physics and other sciences [2].

## **1.2. Variety of common devices and mechanisms for measuring time**

Available devices are mainly based on mechanical mechanisms driven and regulated by mechanical means. These are clocks and devices using gears, spring driving and a mechanical movement regulator. In the recent decades the progress in electronics and studies of crystal properties resulted in the adoption of a range of electrical and electronic clocks based on the quartz generator [2]. This is a movement regulator based on the exact vibration frequency of the quartz crystal when electric current of specific parameters is run through it. This regulator – frequency generator connected to a suitable electronic integrated circuit, which provides vibrations at 1/sec Hz is driving a mechanical mechanism with hands indicating time or when the clock is completely electronic – provides digital display [2]. Most electronic clocks combine the electrical current drive with common mechanisms of completely mechanical clocks. These are the devices measuring time in the power consumption indicators, electrical panels and cars where the impulse quartz generator is also used. There are devices and equipment indicating time in a purely electronic way or involving other mechanical mechanisms as relays, and time switches [2].

## **2. DEVELOPING ALTERNATIVE DESIGN DIAGRAMS OF TIME MEASURING DEVICES**

In this book alternative schematic diagrams for the time measuring devices along with their manufacturing and part design and technology have been developed. This objective has always been a challenge to specialists and those who have developed clock mechanisms to the described level. Despite of what has been achieved, available devices should also be revised and improved to fully meet the requirement of usage in modern society. These are higher accuracy requirements, production efficiency, durability, reliability, appearance, safety and environment considerations. Presented here are possible alternative schematics of such time measuring devices.

### **3. Diagram 1**

#### **3.1. The designer's logbook**

A clock device could be made using an idea close to the idea that the pendulum clock designers and creators had. If a pendulum having a bar and

weight at the end is adopted this will look very much like the well-known home clock. We planned to use the attractive and the repulsive force that could be induced in a certain sequence by an electrical magnet [2].

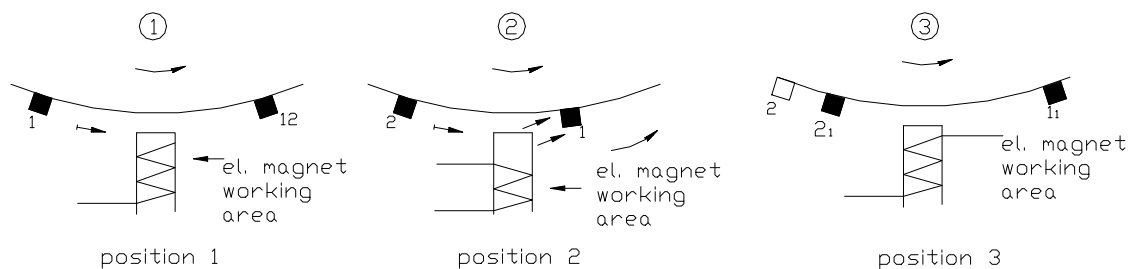
It would be suitable to use electro-magnetic forces and some permanent magnets built into a sufficiently large wheel and thus induce rotation having a constant angular speed  $\omega$  or interrupting but uniform for 360° rotary motion.

The idea begins to shape as an electrical magnet, which is fixed and consecutively positioned at equal angles along the circumference of a pendulum permanent magnets, which move towards or away from the permanent magnet.

A diagram for such a sketch was made. The difficulty is in attracting the permanent magnet along the arch towards the electrical magnet and then having the electrical magnet repulsing the permanent magnet in the direction of rotation [2]. The arrangement would be possible if the direction of the magnetic field of the electrical magnet is changed by bringing the permanent magnet – for example 1, in the position where the changed magnetic field would repulse it in the direction of rotation of the pendulum wheel.

We elaborated the idea implementing a clamp wheel fixed to the pendulum by a clamp, which is simultaneously an electrical switch switching the direction of the magnetic field. This provides for: first, attracting the magnet to the electrical magnet at a position where it can then continue in the same movement direction, and secondly, holding in the initial position for attraction and repulsing.

To avoid movement interruption or return of the pendulum backwards, the clamping positions should be arranged so they can provide the suitable impulse at the suitable moment. The conclusion is that the number of clamping positions should be twice the number of permanent magnets. We decided to use a 2-position electrical switch clamp [2].



**Graphic 1 Electric magnet working area.**

Now that we solved the issue with the rotation speed regulator I decided to adopt an aerodynamic resistance via a blade. Speeding up rotation is an undesirable possibility. The air resistance of radially positioned blade or blades shall limit any uncontrollable increase or change in speed – movement uniformity.

$$R_x = C_x \frac{\rho \cdot V^2}{2} \cdot S$$

A negligible increase in rotation speed results in abrupt increase of air resistance  $R_x$ . Changing  $S$  (blade surface area) or resistance coefficient  $C_x$  could control the speed  $V$  and  $\omega$  (the angular speed) of the pendulum in this case, until the indication is coincident with the correct present time.

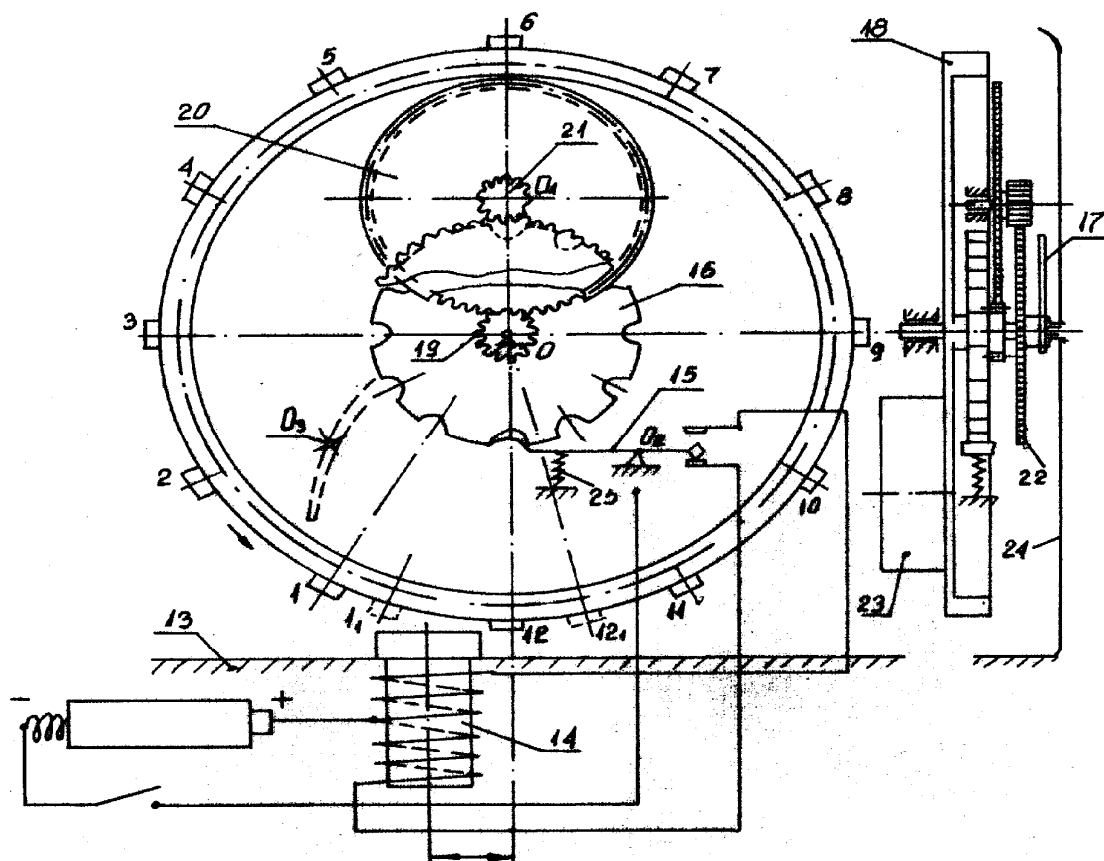


Diagram 1 is created. This regulator type could replace available mechanical regulators. The electrical diagram is not complicated to make but could be sophisticated by electronic experts. It is possible that some corrections in the electrical magnet and electrical part of the diagram are necessary but provided the requirements for the mechanical part and kinematics of movement are kept [2].

The device could be made using available standard parts and a few ingenious ones and I do not expect the cost would be high. Power supply could be simple and efficient using an ordinary 1.5V or 4.5V battery. It might be necessary to use a condenser or an additional coil of the electrical magnet. The blade can rotate around a point somewhere in its middle so its radial position and resisting moment of the pendulum rotation could be changed.

### 3.2. Arrangement

A time indicating device is shown having a central indicating dial axle and driven by electric current with no special electronic circuit and aerodynamic regulator.



**Fig. 1 A device with a central indicating dial axle and driven by electric current.**

The support 13 carries an electrical magnet 14 having a DC current supply and two oppositely wound windings both ends of which are connected to the two terminals of the reversible electrical switch 15 which is also a mechanical positioning clamp on the dial axle. The disc 18 is seated on the support 13 above the magnet and the central axle of the disc coincides with the axle of the dial and the indicating hand 17. Mounted at equal intervals (30°)

along the circumference of the disc 18 are the permanent magnets 1 thru 12 which move past the electrical magnet 14 with each rotation of the disc 16. Mounted on the central axle O of the disc 18 is the wheel 16 having 12 cuts along its circumference as the number of magnets on the disc 18. Engaged on the wheel and on an eccentrically located axle O<sub>1</sub> on the support 13 are two pairs of gears 19, 20 and 21, 22 having a transmission ratio of  $I = \frac{19}{20} \cdot \frac{21}{22}$  as needed for the hand 17 to make one turn around the central axle for 30 or 20 minutes. The wheel 21 is mounted on 20 and 22 - on the hand 17 and freely on the axle O. A radial axle O<sub>3</sub> is mounted on the back side of the disc 18 and a screw is provided in it for fastening the arch vane 23 ensuring rotation around the axle O<sub>3</sub> when the screw is turned.

### **3.3. Operation**

When the contact 15 is actuated getting into one of the cuts in the disc 16 and when power is available in the electrical circuit, for example the magnet 1 is attracted and approaches the electrical magnet 14 as in this moment the contact is interrupted as the positioning clamp comes out of the cut in 16 and the movement of the disc continues by inertia, slowing down until 15 comes completely out of the cut when the other contact of 15 is actuated and the electrical magnet 14 reverses its magnetic field forcing the magnet 1 in the direction toward the point 12<sub>1</sub> which will cause the magnet 2 to go in the position 1<sub>1</sub> which is the start position for rotation to begin. Setting the position of the vane 23 controls the speed, the clamp-switch 15 is pressed against the disc 16 by the spring 25, which is also a means to speed movement up or down varying friction.

### **3.4. Material selection**

The base support is selected of brass sheet usually used in the production of various devices but could also be made of steel; gears are made of plastic, brass or steel. The disc 18 is made of a non-magnetic material – plastic or aluminium alloy as is the vane 23. The axles are steel with standard gears or cast with them if they are made of plastic and are seated in openings made in the support plates.

### **3.5. Design concept**

In order to build a simplified mechanism using standard components and assemblies, maximum simplicity of the measuring device is required and avoiding complicated regulators and electrical circuits [2].

### **3.6. Details of standard parts and components**

Such parts are all necessary coupling elements, the contact 15, the spring 25 and the electrical magnet 14 and also some serially produced gears for various devices along with their axles and the hand 17. A standard dial is also possible to use.

### **3.7. Manufacturing methods**

The common and widely used in device manufacturing techniques shall be used and special processing is only necessary for novel components yet again by

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