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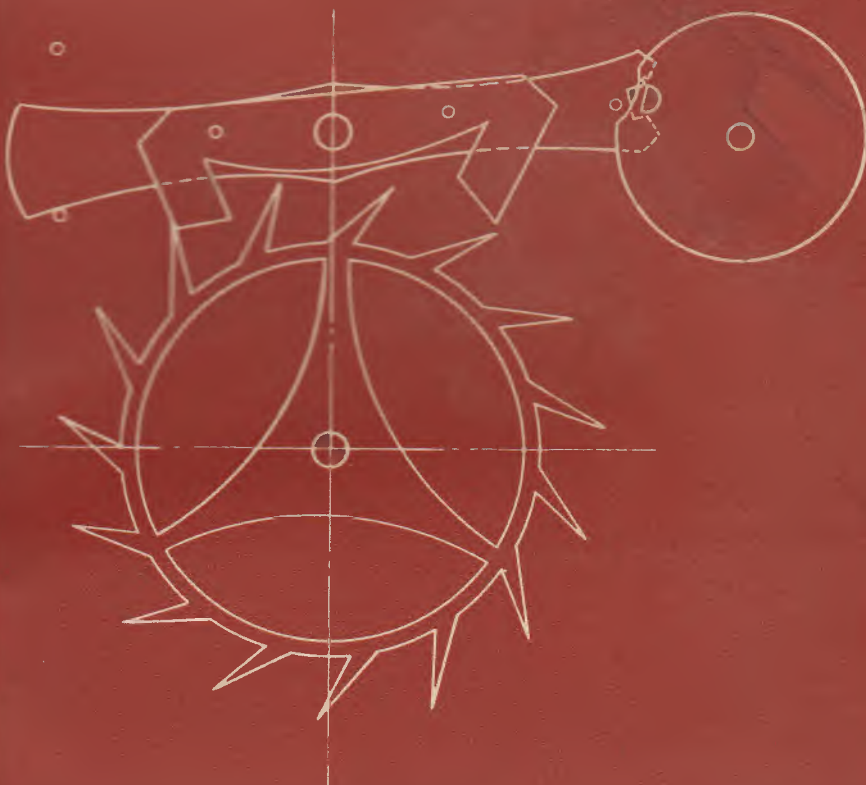
TIME MEASUREMENT

Catalogue of the collection

Science Museum



Science Museum

Descriptive Catalogue
of the
Collection Illustrating

Time Measurement

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Contents

It consists of an electro-magnet through which a current is passed every half minute by the action of the master clock. The electro-magnet attracts an armature which is mounted on a lever carrying a pawl, and when the current ceases to flow, the armature moves away from the electro-magnet, under the action of a spring, and the pawl moves a wheel of 120 teeth, carrying the minute wheel, through the space of one tooth.

A click is mounted on an arm which carries a pin engaging with a semi-circular notch in the lever carrying the pawl, and above the latter there is a stop. This arrangement prevents the wheel being moved more than one tooth at a time, and also ensures that the wheel is positively controlled throughout the operations.

Free Pendulum Clocks

432 Bartrum's free pendulum clock

A clock first described by C. O. Bartrum of Hampstead in 1917, embodying the principle of the free pendulum and slave clock first employed by Rudd in 1899. It was probably the first clock of this type to work reliably.

The free pendulum, on the left, swings freely between impulses, and receives an impulse of a fraction of a second's duration every minute; after the impulse it transmits a synchronising signal to the slave clock, on the right. At the end of the ensuing minute the slave clock releases the next impulse to the free pendulum.

The impulse imparted to the free pendulum is a gravity one of constant amount, and the lever which applies the impulse is released by an electro-magnet operated by the slave clock. As the impulse arm falls away after giving the impulse, it makes an electric contact which transmits a synchronising signal to the slave clock and also actuates an electro-magnet which restores the gravity arm to its rest position. The slave clock then measures out the ensuing period of just under 60 seconds before it releases the free pendulum's impulse arm for the next impulse. As described in an adjacent label, the nature of the synchronising action is such that any error arising in the slave is rocked with decreasing amplitude until it has disappeared and the two pendulums are exactly synchronised again. The synchroniser has the great theoretical merit of correcting both the rate and phase of the slave. The slave clock itself, on the right, is a weight-driven timepiece with dead-beat escapement.

[See *Proceedings of the Physical Society of London*, vol. 29, p. 120, [1917).

433 Bartrum's barometric compensator

Variations of barometric pressure affect the time of swing of a pendulum in two ways. High pressure, leading to high air density, buoys up the pendulum, reducing the effective value of gravity and so slowing the

The count-wheel carries a pin which is pressed against two blades every minute and so makes the contact. An armature is then attracted to an electro-magnet and one end of a long flat spring is pressed against the pendulum by a connecting lever, so imparting an impulse.
The energy required for making contact is taken directly from the pendulum.
[See *British Patent Specifications No.* 8,830 of 1893 *and No.* 10,393 *of* 1899.]

430 Synchronome master clock

An example of the type of electrical master clock developed and patented by F. Hope-Jones in 1905-7 and since widely used. It is intended to transmit electrical impulses every half minute to a number of distant 'impulse dials', and its design is such that the transmission of the impulses does not interfere with the accurate time-keeping of the master clock. The actual clock exhibited is a relatively modern one, but it differs in no essential feature from the 1907 model.
The pendulum beats seconds, and mounted upon it there is a light hinged arm which is provided with a jewelled pin which at every swing to the right engages with a 'count-wheel' of 15 teeth and turns it through the width of one tooth (at each swing to the left the jewel rides lightly over a tooth of the wheel). The wheel therefore makes a complete revolution every half minute. The wheel carries a vane which once every revolution engages with a catch and releases a hinged gravity arm carrying a roller. This roller then falls upon an inclined face mounted upon the pendulum and, as it rolls down the face, imparts a mechanical impulse to the pendulum. Immediately afterwards a tailpiece on the gravity arm meets a contact mounted upon the end of the armature of an electro-magnet and closes a circuit containing the coils of the electro-magnet and also of the electro-magnets of the connected dial mechanisms. The electro-magnet of the master clock is therefore energised, pressing the contacts together and pushing the gravity arm upward. The armature soon meets a stop, but the momentum of the gravity arm causes it to continue in motion upward until it is again locked upon its catch. The contact is thus sharply broken when the armature reaches its stop.
The method employed ensures an impulse of invariable amount being given to the pendulum every half minute, and gives a decisive 'make of electrical contact, a firm pressure throughout its duration, and a sharp 'break', so that a single well-defined electrical impulse is sent out to the dials.
The Synchronome clock exhibited is serving as a 'slave' to the adjacent Shortt free pendulum clock and is synchronised by means of the Shortt synchroniser.
[See *Electrical Timekeeping*, by F. Hope-Jones.]

431 Synchronome Dial

An example of the impulse dial mechanism employed in the Synchronome system of electric clocks.

pendulum; the high density also increases the frictional drag and produces a further slowing effect. The first effect can be calculated fairly accurately, and for a pendulum with brass bob amounts to about 1/5th second per day for each 1 inch rise of the mercury barometer; the second effect depends upon the shape of the pendulum bob, but for a cylindrical bob is roughly equal to the first, so that the total error is about 2/5th sec./day for 1 inch rise of pressure. Bartrum's compensator, first described by him in 1929, is intended to compensate this effect.

It consists of a pile of vacuum boxes (as employed in an aneroid barograph). The bottom of the pile is fixed to the pendulum rod, while the top carries a weight. A rise of barometer causes the boxes to contract under the increased pressure and so to lower the weight. If the compensator is mounted well above the mid-point of the pendulum rod, lowering the weight will speed it up, and the amount of speeding can be adjusted to compensate the slowing described above. The actual movement of the weight is about 1/40th inch for 1 inch change of barometric pressure.

[See *The Practical Watch and Clock Maker*, 15th March, 1929, and *Journal of the British Astronomical Association*, vol. 44, No. 6 (1934).]

434 Shortt free pendulum clock

This type of clock, made by the Synchronome Co. Ltd., was perfected by W. H. Shortt, working in conjunction with F. Hope-Jones and the Synchronome Company, in 1921-4. It forms the practical realisation of the principle of the Free Pendulum and Slave Clock, illustrated by Rudd's pioneer free pendulum clock which is exhibited nearby.

The best mechanical timekeeper known is a pendulum swinging freely under gravity, but in order to convert such a pendulum into a practical clock the pendulum must be sustained in motion, so that its oscillations do not die down, and the swings must be counted. In ordinary clocks the sustaining and counting functions are both carried out by the escapement and clock mechanism, but the free motion of the pendulum is considerably interfered with thereby, with a consequent loss of accuracy in timekeeping.

In the Shortt clock the two functions are carried out by a subsidiary or 'slave' clock—a standard Synchronome clock, which in this case is mounted to the left of the free pendulum. Every half minute the slave clock transmits a short electrical impulse to the free pendulum, energising an electro-magnet which releases a catch and allows a jewel mounted on a light arm to fall upon a small wheel mounted on the free pendulum. As the jewel rolls off the wheel it imparts a light impulse to the free pendulum, this impulse being all that is required to make good the energy lost by the free pendulum during the preceding half-minute. After imparting the impulse the light arm releases a heavier arm which falls into an electrical contact and is restored to its original position by an electro-magnet; the same current which operates this electro-magnet passes through the operating coil of the Shortt synchroniser on the slave clock. The slave clock is thus corrected so that it will release the gravity arm at the correct moment at the end of the next half-minute.

The free pendulum, therefore, swings entirely freely except for the fraction of a second every half-minute during which it is receiving its impulse. The impulse given is strictly constant in amount and is given symmetrically at the mid-point of the swing.

Shortt clocks were the standard timekeepers at Greenwich Observatory from 1925 to 1942, when they were superseded by quartz crystal clocks. [See *Electrical Timekeeping*, by F. Hope-Jones.]

435 Shortt 'Hit-and-miss' synchroniser

This synchroniser, patented by W. H. Shortt in 1921, enables the Shortt free pendulum clock on its right to synchronise this Synchronome clock, which is serving as a 'slave' to the free pendulum.

The pendulum of the slave clock is fitted with a vertical leaf spring which normally swings just clear of a projection on the armature of the synchronising electro-magnet. If, however, the pendulum of the slave is late the armature will be pulled down just before the instant at which the spring is passing it, the two will engage, and the bending of the spring will apply a force to the pendulum which quickens the ensuing half-swing by one two-hundredth of a second. The rate of the slave clock is so adjusted that this process effects approximately twice the amount of correction needed, so that at the expiry of the next 30 seconds the slave pendulum will still be ahead of time and its spring will therefore be just past the tip of the synchroniser at the moment of operation. At the end of a further 30 seconds, however, synchronisation will again be effected. 'Hitting' and 'missing' thus occur roughly at alternate half minutes.

Self-Winding Clocks

436 Self-winding electric clock

Invented by Chesters H. Pond, of Brooklyn, New York, in 1881. It is driven by a small rotary electric motor which winds up a spring hourly.

437 Self-winding electric clock

In this clock, which was invented by Dr. Hermann Aron of Berlin in 1892-4, a light tumbler switch is operated by the running down of the clock train; an armature then rewinds the driving spring and replaces the switch.

This self-winding action was primarily designed to operate the Aron electricity meters, several types of which are exhibited in the Electric Power section of the Museum.

438 Self-winding electric clock

In this clock, made in 1898 by the National Self-Winding Clock Co., USA, the contact for closing the circuit which excites the operating electro-magnet is made by mercury in a small sealed tube.

The electro-magnet is laminated and winds up both 'going' and striking' trains.

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