An Introduction to Electric Clocks

by Michel Viredaz

Translation by David Read

The following text is a revised version of a French article published in *Chronométrophilia* No. 51, which is a publication of the Swiss Association for the History of Time Measurement.

This article is concerned exclusively with clocks, and not electric or electronic watches, which represent a totally different subject. The clocks discussed here are powered directly or indirectly by electricity, and our historical description concludes with the arrival of electronics, which we define here as the introduction of semi-conductors in an electric circuit. In other words, we will cover approximately the period 1840-1970.

This article is aimed at clock amateurs, who often know little or nothing about electric clocks. Such clocks are only known well by a small circle of enthusiasts, despite their enormous interest, and the fact—as we will discover—that they are much more varied in their principles than clocks that are purely mechanical.

Finally, but modestly and only for a better understanding of the text, we would like to make it clear that we are looking at the subject from a Swiss point of view, which may explain the choice of examples and emphasis in the text.

We will look in turn at the following themes: classification, history, examination of the different principles, with examples, and sources of documentation.

Classification of Electric Clocks

It may appear a little off-putting, but classification is a necessary approach if we want a clear overview of such a complex subject. The first example of systematic classification is for Swiss patents found in *Inventions-Revue,* 1908-1909. It is interesting in that it shows the spirit of the time but is, nevertheless, insufficient for a retrospective examination of the subject. After Class A (devoted to mechanical horology), Class B (to cases), and Class C (to specialized machines and tools), there are no less than four (!) classes for electric horology:

- Class D: Electro-magnetic independent clocks, divided between "direct action" and "indirect action."
- Class E: Systems for the unification of time by electricity (with five subsections).
- Class F: Electric apparatus for the measurement of fractions of a second (to make a special class of these rare but wonderful machines—like the chronoscope—was a real honor for Messrs Hipp and Favarger!).
- Class G: Electric mechanisms for giving time signals.

For our purpose we prefer to use a more detailed classification based on three kinds of criteria, as follows:

A functional classification:

- Independent clocks - self-contained instruments giving the time at a given place.
- Master clocks - clocks with a system of electrical contacts to enable the transmission of time impulses to more or less distant secondary clocks.
- Secondary clocks - those instruments receiving the above-mentioned impulses.
- Synchronous clocks - which are in fact nothing but secondary clocks for which a master clock is the generating station.

A classification by type of movement, which can apply to both independent and master clocks:

- Clocks driven by electro-magnetic impulses to the pendulum.
- Mechanical clocks with weight or mainspring rewound by electricity - through a motor or an electro-magnet, at short intervals or with power reserve.
- Clocks in which a mechanical impulse is applied directly to the pendulum - through gravity, spring, or electro-magnet.
- Special and anecdotal ideas of construction.

Finally, a classification according to the source and characteristics of the electrical supply:

- Low voltage (1.5-60V) or mains (110-220V).
- Direct current (usually low voltage) or alternating current (usually mains).
- Mains, with or without transformer and/or rectifier, or battery, rechargeable or not.

With such a global overview, it will now be easier in the following pages to examine characteristic constructions, without the risk of confusion between the many varieties of electric clocks.

But before that, let's have a look at history.

History

The first question that comes to the mind of everyone is, "Who was the inventor of the electric clock?" As usual for great inventions, the idea was everywhere in the air around 1840, and numerous works had been undertaken by people like Wheatstone, Steinheil, Hipp, Breguet, Garnier, and many others.

Under the initiative of British enthusiasts, the idea has become well established in literature that Alexander Bain was the "father" of electric clocks. Bain started, but did not finish, an apprenticeship as a clockmaker and became interested in electricity very early, around 1830. After a long controversy with Prof. Wheatstone, who tried to appropriate Bain's invention for himself, Bain registered his first patent on October 10, 1840. Bain was certainly a genius and a visionary. Numerous applications of electricity to clockmaking and time are envisaged in his texts and patents, but he did not succeed in establishing a real production series or an industry, as did Hipp, who was of German origin, in Switzerland during the same period.

But before we discuss Hipp, let's remind ourselves that research on electricity had already started in the seventeenth century. An Italian, Prof. Rami, made the first electro-static clock in 1815. William Sturgeon, a British citizen, invented the electro-magnet, which was indispensable for electric clocks, in 1825, and Volta invented the battery in 1800.

Matthias Hipp (1815-1893) was born in Wurtemberg, Germany. He apprenticed as a clockmaker and worked in a modern factory: he had met the son of the owner coming back from further training in Switzerland. He also went to the French-speaking part of Switzerland to improve his professional education, stopping briefly in Sankt-Gallen in 1834, where it is said that he invented his famous "toggle-escapement" —in fact a switching contact and not an escapement in the usual sense of the word—during a night of insomnia. He arrived in Saint-Aubin, near Neuchâtel, in 1835, where he improved his skills for a few years before returning to Germany. In 1841, at the age of 28, he created his own factory in Reutlingen, Germany. It was in Reutlingen that he finalized his first Hipp-toggle clock. He presented it in Berlin at an exhibition in 1843, with the brief mention, "A clock which has its movement below the pendulum." See Figure 1. He also invented a small motor and built the chronoscope and the registering chronograph, two instruments used for the measurement of very short time periods (the class F mentioned above).

The most remarkable fact connected with the Hipp-toggle clock, apart from its extraordinary ingenuity, is that it was successful enough to have been made and sold for over a hundred years without any change in its operating principle. What other invention can claim the same longevity?

In 1852, Hipp was named by the federal government to head the National Telegraph Workshop and to be the technical manager of the Telegraph Administration, a great honor for a foreigner. In this position he continued his inventions for eight years, but not without some animosity against him, since he was both well known and his office was profitable, two major crimes for a high civil servant. G.A. Hasler, his former assistant, succeeded him and took over the workshop when it was privatized.

In 1860 Hipp went to Neuchâtel, where he created a small telegraph and electrical apparatus factory. This was the real beginning of electric horology, which now became established in the practical sense, after two decades of laboratory research in Europe. The company developed rapidly, and Hipp retired in 1889, leaving the responsibility to A. Favarger and M. de Peyer. From this time until 1908 pieces are signed "Peyer & Favarger, successors of M. Hipp," after which Peyer retired and the company became Favarger & Cie (& Co.), then Favarger & Cie S.A. (Ltd.) in 1923, and finally Favag S.A. in 1927. The Favag clock business, which produced quartz clocks in the latter years, was liquidated in the early 1990s, the servicing of the last existing clocks was given to a former competitor.

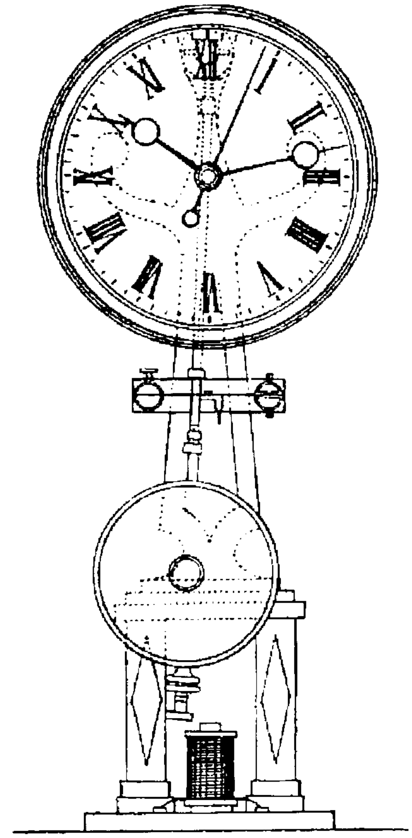


Figure 1. General scheme of a Hipp clock with 1/2 sec. pendulum of the second half of the 19th century. One can see the contact in the middle of the pendulum and the electro-magnet below it. These clocks exist with or without the master clock function.

Another important person in the Swiss landscape of electric horology is David Perret, a pioneer of electric winding. He was the son of an industrialist in the watch business, was a high school mechanical engineer from the Swiss Polytechnic Institute of Zurich, and an officer in the army, and a politician. He registered many patents in his name. After having spent some years concentrating on the mechanization of watch production, he became interested in electric clocks and developed an original system of double contact switching, to reduce sparking, for rewinding a weak mainspring once a minute. He died on September 18, 1908, and, sadly, his company was liquidated some years later.

Listed below are important dates for electric clocks to conclude this brief review of their history.

1856 - the first electrically wound clock by Louis F. Breguet.

1862-64 - the first electric networks for clocks in Geneva and Neuchâtel.

1885 - the invention of the Ferraris motor (much used in electrically wound clocks, for example, Zenith).

1912 - the first radio time signals from the Eiffel Tower.

1916 - the synchronous clock by Warren.

1921 - the Shortt clock (the top of precision before quartz).

1930 - the first quartz clocks.

1955 - the atomic clock.

60s and 70s - the move from "electric" to "electronic" and the end of our little review.

We can now go to the study of the different types of electric clocks.

Electro-Magnetic Impulse to the Pendulum

This idea first appears, although in a rather primitive form, in the first patent of A. Bain in 1841. We find it also in the Hipp clock of 1842. In these clocks, an electro-magnet (i.e., a coil with a central core of soft iron) is usually placed below the pendulum, which is also terminated by a piece of iron. An appropriately positioned contact (this is easier to say than to do) switches the current through the coil during the descending period of the pendulum, close to the vertical, giving it a magnetic impulse to replace the lost energy. See Figure 2.

One realizes that the pendulum is, therefore, both the regulating oscillator, as in mechanical clocks, and also serves as the clock's motor. The pendulum and its contact can work alone, without any wheels. The transfer of time to the dial can be done in two ways, either mechanically, with an index wheel and a pawl, the movement being then just an impulse meter (a very simple system, not needing to be described to clock-making specialists), or through an electric contact giving impulses to a secondary clock (see the "secondary clocks" chapter). This second solution has the advantage of leaving the pendulum almost free. It is generally used in high quality clocks (e.g., all Favag clocks with 2/3s pendulums).

Féry, in France, modified the electro-magnetic motor system by using a fixed impulse coil without a core, through which a permanent magnet attached to the pendulum oscillates. This system has been widely used in France by Brillié, ATO, and many others. The same principle is used by the Bulle clock, which employs, by contrast, a coil fixed to the pendulum and a magnet fixed on the movement or baseboard. See Figure 3.

A critical characteristic of these clocks is the contact that switches on the current needed to maintain the pendulum in oscillation. In most clocks of this type, the contact closes and an impulse is given at every oscillation, or half-oscillation as with Frank Holden, and a pawl fixed to the pendulum drives the wheel train. The genius of Hipp was to invent a toggle switch system that makes an electrical contact only when the amplitude of the pendulum falls below a critical threshold, thus freeing the pendulum from a lot of unnecessary mechanical interference. See Figure 4.

In practice, impulse is given every 30 to 120s, depending on the model. As already mentioned, this system has been perpetuated in Hipp-Favag clocks for about a century, and copied many times with all sorts of variations (English Magneta, Siemens, Cyma, Scott, Vaucanson, etc.).

Until now, we have been speaking only of pendulum clocks. However, smaller clocks and watches with spiral-balances have been made on the same principles,

Figure 2, above. One-second pendulum clock of the Hipp type signed Favarger & Cie, about 1910. The dial is an oscillation meter linked to the pendulum by a fork and gathering system.

Figure 3, below. A Bulle clock of the first period, around 1920, still signed MFB (for Maurice Favre-Bulle, who developed it). One realizes that the trademark comes from his name (he was French but Favre-Bulle is a typical name from the Swiss Jura) and has nothing to do with bulls. The coil attached to the pendulum and the permanent magnetic bar fixed to the case are clearly visible. The contact is made by a silver pin carried on the pendulum rod that engages a pivoted notch on the rear of the movement. The company lasted until 1955, when its founder died.

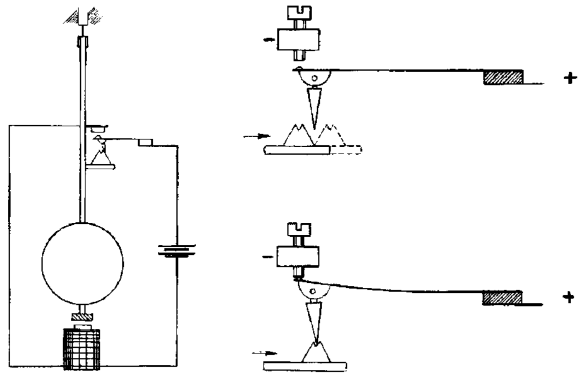


Figure 4, above. The Hipp toggle contact. On the left, the general scheme; on the right, how it works. As long as the pendulum amplitude is sufficient, the pallet slides from side to side over the notched jewel; however, when the amplitude falls to a certain threshold, the pallet engages the notch and lifts the contact spring. At this moment electricity flows through the coil and gives an impulse to the pendulum, sufficient for the next 30-120 vibrations.

as is the case in Switzerland and Germany, e.g., the well-known and more recent movements, named Orel and Sterling. In this category, we can also mention the Eureka and some others like Cauderay—an electrician from Lausanne in Switzerland, who became established in Paris—who used a very large and decorative balance. See Figure 5.

Finally, we note that the development of timekeepers based on the principle of magnetic impulse accelerated when the transistor replaced the electro-mechanical contact, and it is in this category that the electronic revolution was started (ATO and Kundo).

Electric Winding

The clocks described in this section are mechanical clocks of any type, with pendulum or balance, weight or mainspring, in which the winding is done electrically instead of manually. Some systems also exist for the later modification of a mechanical clock.

The winding can be done either with an electric motor, which winds many turns of the weight or mainspring at each contact, see Figure 6, or with an electro-magnet and armature, which winds small portions through a pawl, but the final result is the same. See Figure 7.

Some clocks are wound at frequent intervals, once a minute as with David Perret, or at long intervals as in tower clocks. Some pieces have a power reserve; others can only go the period between two windings, for example, the small Reform movement See Figure 8.

The power reserve is obtained by a weight or a spring, kept more or less fully wound through frequent switching, but which can go for the whole length of the spring or weight suspension during a power outage, the complete winding being made automatically when power reappears. In this category of clock, there is a need for a system that switches on or stops the winding at the right moment. In Moser-Baer and many other clocks, which use a powerful motor driving the rewind via reduction gearing, this is obtained with a contact linked to a sliding screw that is fixed to the going barrel. In some weight-driven clocks, the contact is switched by the weight itself when it goes up and down. In Zenith clocks, and others using a weak motor like the Ferraris (the one seen in most electricity meters), the current is not interrupted as it is unnecessary for just 2W, but the wheel is stopped by a lever covered with felt, constructed on the same principle as above. The result is an almost continuous winding in small sequences of 2-3s. The motor only goes for a long period after a current interruption. See Figures 9 and 10.

A very particular and rare case is the O'Keenan clock made in Paris, in which the motor turns continuously, its speed being regulated by the escapement itself through a buffer spring so that it continuously gives just the necessary energy to the clock. See Figure 11.

Of course, in all these pieces, winding must be designed in such a way that it does not interrupt power to the escapement during the winding period, but this is a classic problem, well known in horology, especially in precision or large clocks. Regarding large clocks, let's mention wind-

Figure 5, below. Cauderay's clock movement, end of 19th century. The electro-magnet acts on a mass fixed to the pendulum shaft; the contact is derived from the Hipp toggle.

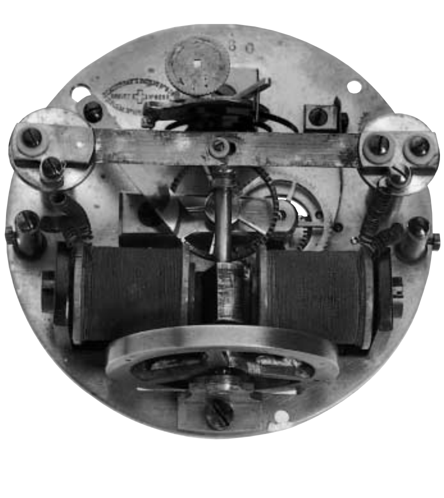


Figure 6, below. Bürk clock from the Black Forest, around 1960. A small motor, switched by a mercury contact, does the winding.

Figure 7. An EZ clock of the 1930s (EZ = Elektro-Zeit, later becoming T&N = Telefonbau & Normalzeit). In contrast to the common pawl and ratchet rewind system found in many electrically rewound clocks, the electro-magnetic system in the EZ clock is composed of a two-pole armature that is pivoted to rotate through about 25° into alignment with the magnetic field when the contact is closed and returns to its resting position under the force of a weak spring when the contact is opened. This sudden rotational energy is transferred through the surface of the contact to a large flywheel that winds up a small weight, sufficient for driving the anchor escapement and pendulum for a few minutes until the process is repeated. This electro-magnetic “motor rewind unit” is a discreet module from which the pendulum also hangs, and the conventional anchor movement comprises another easily removable module (not in the picture) that counts the pendulum beats and displays the time on a dial. These two units are linked together by a helical spring through which energy is transferred with maintaining power. The clock illustrated has, in addition, two wheel trains linked by a differential, one for the time and one for the secondary clocks contact, revolving once per minute of a half-rotation and reversing the polarity at the same time.

Figure 8. Small Swiss travel clock signed Cosmos, using the cheap version of the Reform movement, based on patents from 1928 and 1929. It has a spiral balance with a spring giving a power reserve of some three minutes to the going train. When the spring reserve is almost exhausted, a small arm linked to the barrel closes the contact and the electro-magnet gives a kick to an inertia arm with two balls at the ends. This winds up the spring with a pawl and ratchet and at the same time interrupts the contact. This movement is more commonly found in its high quality version, with 15 jewels and Breguet hairspring.

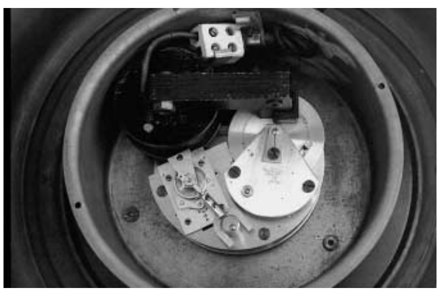


Figure 9. Wall clock with Ferramo balance movement, made by T. Baeurle & Sons, Sankt Georgen, Black Forest, using a Ferraris motor for the winding power. The main advantage of this motor is that it is silent, a quality that not all electric clocks can claim to have!

Figure 10. Precision clock with heavy pendulum beating seconds, from the Zenith company. The movement is weight driven. The winding module is separate, based on a Ferraris motor, and placed below the movement. It starts as soon as the weight falls down by only a few millimeters, assuring a permanent power reserve of many hours. The movement is conventional but of top quality with a jewelled Graham anchor. The same clock also exists in a manual version.

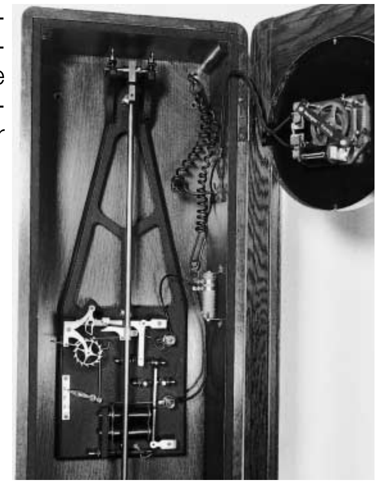
Figure 11. Clock made by O’Keenan in Paris, around 1905. It has a distinctive small motor known by the “OK” name and widely used in gas meters. It turns permanently, winding a buffer spring, which in turn gears a conventional movement. The escapement maintains the motor at a speed such that it never needs to stop.

ing through a continuous Huygens chain, often used to electrify old movements. Also, by adding magnetic synchronization of the pendulum through a radio-controlled clock, antique tower movements can be modernized without any non-reversible modification, a very important concept in restoration.

Direct Mechanical Impulse to the Pendulum

Included in this class are all clocks in which the oscillation of the pendulum is maintained by a mechanical, as distinct from electro-magnetic, impulse given directly to it, excluding, of course, the mechanical impulse through an escapement, as in mechanical horology. In more popular terms, we could speak of clocks receiving a flick from time to time! British clockmakers are the kings of this technology, with numerous high quality examples (e.g., Synchro-nome/Shortt, ECS/STC, Gent/ Pulsynetic, Gillett and Johnston, Telephone Rentals/Princeps). Continental clocks made on the same principle are somewhat less well known.

Figure 12, right. Classic Synchronome clock of the 1940s, made with little modification since the beginning of the century. Clearly visible is the single wheel that is gathered by a small jewelled arm fixed to the pendulum, as well as the gravity arm and the pallet on which it falls, before being kicked up again by the electro-magnet. A non-polarized secondary movement is in the door and serves as the main dial. Many other slaves can be placed in series on the same circuit.



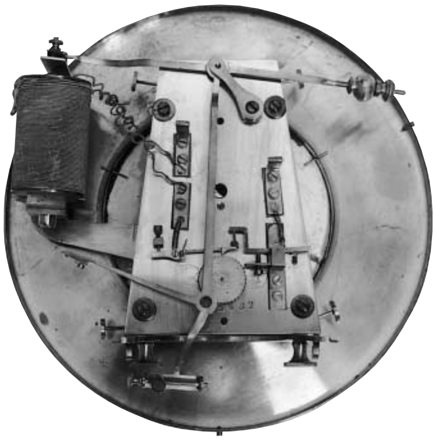


Figure 13, left. Rear view of the movement made around 1928 by W. Zeh of Freiburg in Breisgau, here placed on a Bergeon support for the photography. One can see the lever made of a spring blade and the needle pressing on an arm fixed to the pendulum. The electro-magnet is inside the movement and cannot be seen here. It advances the wheel train at the same time as it tightens the spring.

Before we examine some of these clocks, we should mention that the impulse may be given in three different ways:

- By gravity - with electro-magnetic re-cocking of a gravity arm. This is the best solution, giving constant power (Synchronome, etc.).
- By a spring, tensioned in advance by an electro-magnet and released by a count wheel. Froment may well have used both gravity and spring, but this is not clear from existing literature.
- By a lever moved directly by an electro-magnet.

In the first group, the stereotype is, of course, the Synchronome by F. Hope-Jones (Figure 12), a wonderfully simple clock giving excellent chronometric results with a minimum amount of mechanics (one single wheel).

In this clock, the pendulum carries a lever with a gathering jewel that indexes the single 15-tooth wheel one tooth at a time. Once every revolution, every 30s, the wheel releases a gravity arm that falls onto a pallet attached to the pendulum rod, giving it the necessary energy at the best moment. At the end of its downward movement the gravity arm touches an electrical contact on the armature of the electro-magnet and is thereby brought back to its upper position. One or more secondary dial clocks impulsed every 30s, including the main one on the door of the Synchronome itself, may be placed in the same switching circuit.

The Shortt clock was derived from the Synchronome and was the highest precision clock before the arrival of quartz oscillators. It is composed of two clocks, a master under a vacuum with an almost free pendulum, and a synchronized slave, which carries all the necessary devices and absorbs all interferences without influencing the precision of the master.

In the second category, we would like to mention the German-made clock W. Zeh (Pega), an attempt in 1928 to design a precision clock for the public at large with the possibility to drive one or two secondary clocks for use in the home, using a short pendulum. See Figure 13. An arm made of a flat spring is tensioned by an electro-magnet, which also drives the minute wheel. The spring is released periodically to give an impulse to the pendulum through a needle leaning on an arm fixed to the pendulum and bearing a jewel. Criticism of this system was made, however, because of expansion of the needle that reduced the expected precision of the clock.

In the third category, we can place at least two great names: Professor Aron, who is better known for his later winding system used by the Heliowatt company, and Campiche of Geneva, whose clocks are highly valued by collectors. In Aron's patent of 1884, an electro-magnet moving an armature gives impulse to the pendulum rod through a fork, which at the same time moves the minute wheel with a gathering pallet. The movement is, again, just an impulse meter. See Figure 14. In Campiche's clock—another single- wheel clock—the electro-magnet gives a flick to the pendulum rod once a minute through an elastic lever. A pawl on the pendulum indexes a 30-tooth count wheel carrying a seconds hand and making one turn per minute. It also carries a contact blade that closes the switch between two contacts, thus providing the necessary electrical contact for both the electro-magnet and for the circuit of secondary clocks, of which one serves as a secondary dial on the door of the case, as usual.

The advantage of all these clocks is their great simplicity, simplicity meaning minimization of interferences and hence, in principle, improved precision and less maintenance.

Figure 14. Aron movement of 1884, signed G. Becker, Freiburg in Schlesien. The electro-magnet is on the left and acts on the pendulum through an arm when the contact closes. The arm is linked to the pendulum and carries a pawl in order to index the wheel train. Interestingly, the dial has a minute sub-dial graduated in number of vibrations (80) and not seconds.

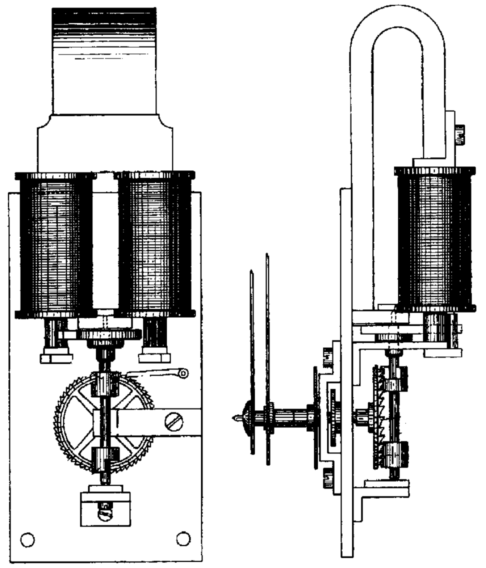


Figure 15. Secondary clock by M. Hipp. Its armature is polarized and rocks from side to side in response to alternating polarity pulses transmitted from the master clock. The wheel train is indexed by driving a verge-like wheel and pallets in reverse. The motion work and dials exist in minutes and seconds versions, in different sizes according to the length of the hands.

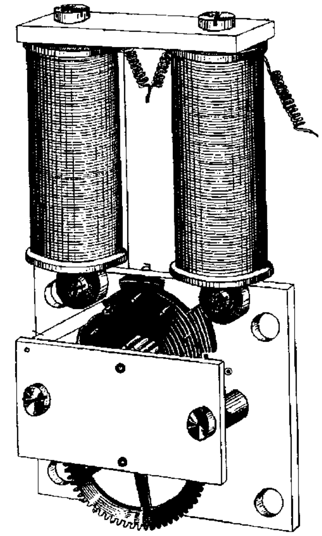


Figure 16. Secondary clock by A. Favarger, successor of Hipp. It has a polarized rotating armature and has been produced for about three quarters of a century in three sizes.

Secondary Clocks

Secondary clocks are not self-contained clocks but are slave instruments that receive the impulses given by a master clock and display them as minutes and hours on a dial. They could never give the time by themselves—numerous amateurs who did not know this have gotten bad deals at flea markets! They need a master clock, which generally gives impulses every 1s (high precision clocks), 30s (typically in France and the UK) or one minute (Germany and Switzerland). See Figures 15 and 16.

The master clock function is independent of the type of slave clock, and all classes described previously can play this role, given the necessary contacts. Even a purely mechanical clock can act in the master's role if fitted with appropriate contacts, and many precision clocks have been manufactured on this basis.

It needs to be remembered that the motion work, or counting system, of a secondary clock must suit the time interval between transmission of impulses, i.e., whether they are 1s, 30s, or 1 minute. In addition, secondary clocks are made to suit both unipolar and reversing polarity pulses to match the system employed in the mother clock.

Therefore, apart from the impulse frequency, secondary clocks can be divided into two large families: polarized and not polarized. Polarized clocks, used mainly in Germany, France, and Switzerland, need alternate positive and negative impulses (usually low voltage). See Figure 17.

The idea is to avoid involuntary jumps of the hands due to a vibrating contact or outside interferences. This means a special inverter device in the master clock, obviously not a simple construction. Non-polarized clocks always receive the impulse in the same current direction. This simplifies the process, but requires a well-designed contact. These clocks were common in Great Britain but less so elsewhere. Nevertheless, they could be found generally, but in small numbers, very early in the deveopment of electric horology, e.g., Campiche, around 1900.

Construction details are very varied and more or less noisy, but most if not all of them use an electromagnet, a system of pawls or rocking pallets, and a traditional wheel train.

The clocks of the Swiss Federal Railways, made by Favag, deserve special mention. They have a seconds hand that stops for about 2s in every minute. In fact, for reasons of simplification and probably cost, they

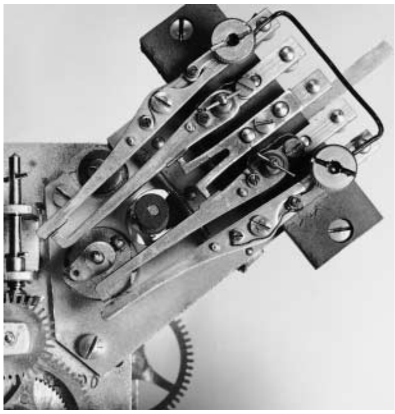
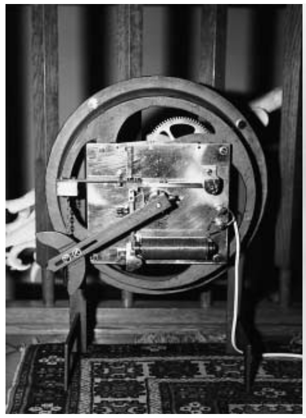


Figure 17, above. Polarity inversion device by Heliowatt. Every minute, a cam seen on the left makes a half-turn, closing the contact alternately on each side, thus reversing the polarity.

Figure 18, below. Tower secondary clock by Campiche of Geneva, end of 19th century. It is unipolar and based on a typical French dial train with an additional plate on which the electro-magnet and the indexing system are fixed. A counterweight serves to balance the minute hand.



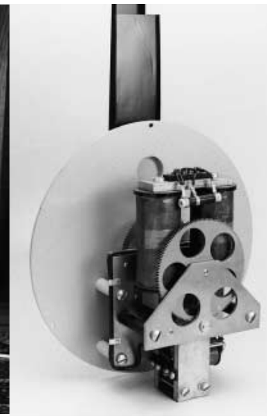


Figure 19, left. Small secondary tower clock by Moser-Baer. It is polarized with an additional system to block the hands between two impulses in order to protect them against accidental, untimely movement. Circa 1960.

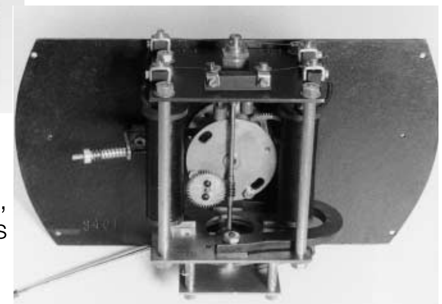


Figure 20, far right. Synchronous clock by Michl, signed Laplace, Czechoslovakia,1920s. It must be started by hand. Thiesen, in his famous series of books, regards it as the first really usable synchronous clock ever made.

were an attempt to make secondary clocks with a seconds hand driven by mother clocks having only minute impulses. There are, in fact, two different types of movements arranged co-axially in these clocks: a normal minutes secondary clock, and a synchronous movement for the seconds hand, which is stopped during each revolution at 58s and is released by the minute contact to begin the next revolution.

There are also very large secondary clocks made for towers and churches that have special requirements, like the weight of the hands, birds who use them as a perch, wind, etc. See Figures 18 and 19.

Favag made a very powerful system with a strong motor driven by the mains, controlled by a secondary clock used as relay. Gent manufactured a system called “waiting-train” for controlling a secondary clock, in which a clock using the Hipp toggle method of pendulum motor has an unusually heavy pendulum that provides enough power to drive heavy hands. The pendulum is adjusted to beat at a gaining rate and gathers the index wheel until a tooth is masked and the gathering is interrupted. At this point the wheel is “waiting” until it’s released by the armature of an electromagnet on receipt of accurate impulses from a master clock. The release occurs once in each revolution of the index wheel, i.e., every 30 seconds.

Before going to the next section mention should be made of ship’s clocks, both master and secondary, that are built in a way that the hour hands can be moved forward or backward in one-hour jumps to accommodate the change of time zone.

Synchronous Clocks

Here, too, one can ask: Are they really clocks? In the same way that most secondary clocks are impulse meters, synchronous clocks are in fact frequency meters. They are made of a small synchronous motor, turning at a speed dictated by the frequency of the AC mains, and are combined with a wheel train to enable the indication of seconds, minutes, and hours on a dial. See Figure 20.

The *conditio sine qua non* is that the mains must have an absolutely stable and precise frequency, which is now the case. This is not to please the owners of these clocks, but because it is indispensable for the interconnection of electric networks. Don’t forget that the frequency is 50Hz in Europe and 60Hz in America. An American synchronous clock will not, therefore, keep time in Europe, whatever the voltage, and a transformer is not enough to solve the problem. One needs to change either the motor or the wheel train.

Apart from these aspects and numerous constructional differences, one can distinguish two groups of synchronous clocks:

- The self-starting ones, which stop when current is interrupted and restart when the current is restored, i.e., running but showing the wrong time. Their supporters claim that interruptions are generally short and that an approximate time is better than no time at all, while their opponents claim that it is an illusion to know time if it is wrong and that it is better to know that one does not know.
- The manual-start clocks. These also stop when the current is interrupted but don’t start again. It is

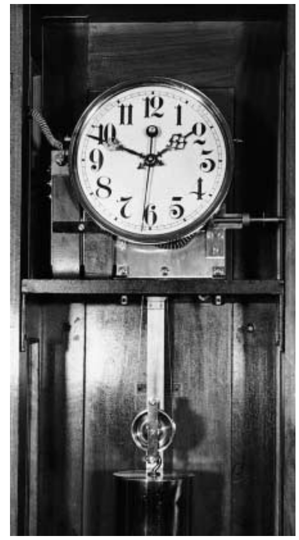


Figure 21. Magneta clock by Martin Fisher of Zurich, around 1905. The inductor (a type of dynamo) is on the left in the picture. Winding is manual. The weight of about 17kg hangs on a steel rope and transmits power by winding a strong buffer spring for the inductor (which needs a sudden and rapid movement to create an electric impulse) as well as a small spring in a barrel for the going train with Graham anchor. Winding should take place daily, and a warning system placed in the case closes a contact when the weight needs rewinding, lighting a small indicator lamp. If the clock is not wound, the pendulum is deliberately stopped, otherwise the secondary clock fails long before the master. This condition arises because when the weight is grounded, the elasticity of the steel rope will keep the movement going for a while, but the energy is insufficient to wind the inductor. Later, during Landis & Gyr time, these clocks were all made with electric winding.

necessary, therefore, to restart these clocks by hand using a button or lever that one would obviously never do without re-setting the hands at the same time.

In our era, quartz clocks and radio-controlled clocks have made these arguments obsolete!

Special and Anecdotal Systems of Construction

Despite the numerous differences in operating principle and design, electrical horologists were not satisfied and felt it necessary to invent some very original additional designs—sometimes interesting, sometimes rather laughable.

Let's begin with a genius, Martin Fisher of Zurich, who in 1899 created the Magneta system, later called Inducta, after his company was taken over by Landis & Gyr of Zug. See Figure 21.

His slogan, translated into English, was: "Electric clocks without battery and without contact." This is very representative of the problems at that time. Batteries could be unreliable and needed a lot of care and good ones could not just be bought at the corner supermarket! Switch contacts became burnt and oxidized, as anti-spark systems, which became common some time later in the form of a resistor associated with a condenser, had not yet been invented. Fifty years earlier, Wheatstone was the first to describe these problems and his electric clocks were the first attempt at their solution by using magneto-electric induction. Wheatstone's clock was a failure because he used the pendulum as the inductor as well as the oscillator.

Fisher's idea was to construct a mechanical clock combined with a separate and properly designed magneto-electric generator between its plates that was driven by a separate train of wheels and released by the going train of the otherwise conventional clock. Every minute his inductor gave a very short (2-3/100 of a second) pulse of current (reversing polarity each time) to a network of secondary clocks. As a matter of fact, only the network is electrical, not the master clock. The first clocks had to be wound by hand; later they were also equipped with a winding motor. The construction is rather heavy, as the inductor needs very strong instantaneous power to create sufficient current. The secondary clocks are also very specialized as they must react in a very short time. This is achieved through a buffer spring between the electro-magnet and the wheel train. Important advice to collectors: all clocks with the Magneta name (apart from the British ones, which are of the Hipp type) are built like this, but not all Inducta clocks, despite the misleading brand name. Later, Landis & Gyr built two ranges of clocks in parallel under the same name and in similar cases: inductor clocks and ordinary motor-rewound clocks with contacts.

At the other extremity of genius, one should mention the well-known Jamin-Zenith patent of 1982, a sweet design for collectors but maybe not the most practical chronometric instrument. See Figure 22.

It is a clock in which the pendulum is maintained in movement by a mechanical impulse—we could have classified it in the corresponding chapter but it is so strange that we prefer to classify it separately—but it is particular in that the impulse is given neither by gravity, an electro-magnet, or a spring, but by the expansion and contraction of a heated wire. Each time the wire cools down (1/oscillation) the increase in tension is transmitted to the pendulum in the form of a flick. There are variants with and without power reserve. Needless to say that these clocks are full of caprices and that the right quality of wire is almost impossible to find today.

To this thermic section, we can also add the Pneuora by Junghans. It is a mechanical clock with rewinding by compressed air through a piston. The air is expanded by heating in a special sort of filament lamp where it is heated by electricity, thanks to a contact placed in the movement. Thus the transmission between the "motor" and the clock is done by air expansion through a pipe. Secondary clocks were controlled in the same way.

Signal Systems

We now leave the primary function—to indicate the time in a visual way—and examine the acoustic signaling of time, primarily in factories and schools. This is usually achieved thanks to an additional contact module added to a clock of any type. Mostly, it is one or

Figure 22, above. Jamin-Zenith clock without power reserve, mid 20s. The dilation wire is in the tube seen on the left. It acts on the pendulum through an elastic lever and a traction wire at the bottom. Contacts are on the top of the pendulum. This constitutes a sort of thermic motor working under 4V AC, independent from the dial, which is, again, just an oscillation meter.

Figure 23, above. Favag master clock with 2/3s pendulum. Late 1920s. Fitted with additional module consisting of a 24-hour contact wheel for actuating signals that are adjustable in five-minute intervals.

several disks turning during 24 hours, with holes for small pins at one or five-minute intervals. These pins then close the contact when necessary. The system can be completed with a weekly program or the adjustment of the length of the signal. See Figures 23 and 24.

Added to synchronous clocks, these systems were also used to switch on the lights, or a radio, or in hotels to remind Reception to wake up the customers at the right time. See Figure 25.

Chimes

Chimes are rare in electric horology and are mostly associated with rewound clocks. They are then similar to mechanical chimes. They also exist in clocks with electro-magnetic impulses (Bulle clock, ATO). The hammers are moved by an electro-magnet, but the counting is by conventional means as in mechanical clocks.

Sources of Documentation

It seems unnecessary to mention a long bibliography here. Most books are rare and expensive, to be found only in the library of enthusiastic specialists. At this point of time, there is still no book written specially for amateurs from the historical perspective, apart from some exhibition catalogues:

Chronatome. La Chaux de Fonds, 1978 (modest iconography).

Aked, Charles K. *Electrifying Time.* London, 1977 (rich documentation).

Figure 24, below left. Signal control box by Favag constructed on the basis of a secondary clock mechanism. There are many models, with one or more lines of signals.

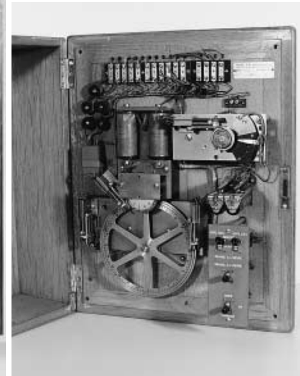


Figure 25, below. American synchronous clock made for hotels. A warning signal can be adjusted by five-minute intervals.

Nederlands Goud-, Zilver-, en Klokkenmuseum. *Elektrische tijdaanwijzing.* Schoonhoven, 1985 (excellent, too).

Zeit und Mikroelektonik. Furtwangen, 1987 (interesting).

150 Years of Electric Horology. NAWCC Chapter 125, 1992 (excellent, widely concentrated on American clocks).

Books are, of course, available from time to time at specialized antique bookstores. Some English ones are interesting, but one must also read German and French books for a real overview of the subject. Many of these books, used for information or in schools at the time, are too theoretical. Only some of them describe real clocks from the market in detail, probably because the authors were too often cautious about providing “free advertising!”

Many articles exist in various journals, but they are difficult to find and assemble. The Internet is a valuable source of information. The present article is to be found with animated pictures and some further links under www.mypage.bluewin.ch/electric-clocks

About the Author

The author may be contacted by email at viredazepal@bluewin.ch.