Technological and industrial aspects of the introduction and operation of Clock networks in Czechoslovakia

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Abstract. *This article deals with the technical aspects of time synchronization in modern society. Specifically, the introduction of uniform time systems in Czechoslovakia, their technological dimension in relation to the post-war production program of the national company Elektročas. It, as the heir to the First Republic company Jednotný čas, took over the technical documentation of the German company Normalzeit after the war, and by obtaining the design templates for the components of the unified time systems, established the technical foundations of its own production program. Later, using this "heritage",it became the leading European manufacturer of cock networks. The key topic of this text is the question of the gain of technology and its development in the specific conditions of the socialist establishment into the products of the unified time system, which in their meaning exceeded the horizon of simple technical artefacts and became symbols of the time and lifestyle of modern man.*

Keywords

History of Technology, History of innovations, Czechoslovakia, Clock networks, synchronized time, time standards, technology transfer; CMEA - Comecon (the Council for Mutual Economic Assistance); metal industry, electrical engineering and armament industry; know-how, centrally controlled economy, 1945-1960.

1. Introduction

Information about the exact time, today so easily obtainable from the display of a mobile phone or other commonly used digital device, was still provided at the end of the 20th century in public space, industry, education and transport mainly by extensive systems of centrally controlled, electrically pulsed synchronized clocks – clock networks. From a technical point of view, we mean systems of synchronized electric clocks that display uniform, centrally distributed time data in factories, public spaces, offices, schools and railway stations - generally in some geographically, structurally, functionally unified units.

The central element of any such system is a source of accurate time information, known as master clock (traditionally mechanical and since the end of the 1970s, electronic), which transmits a time signal in a regular, minute or half-minute rhythm via a cable by an electrical impulse to the peripherals, secondary clocks, which are, technically speaking, mere counters of electrical impulses. Subsidiary clocks in such a system may count from the lower tens to several hundreds. In addition to master and secondary clocks, these often very extensive clock networks may include other devices controlled by mother clocks, sources of sound signaling (school bells, sirens for signaling work shifts in factories), automatic mechanisms for switching on lighting or industrially applied relay systems for switching off machines or other devices, as well as systems for checking and recording employee attendance, known as „punch clock“ or „beepers“. In the mid-20th century, control and attendance clocks, along with clock networks, which they were later incorporated in, became symptoms of the industrial world.

Their era begins at the time of the Industrial revolution, when employees started to be paid not by the work done, but by the hours worked. A new era of economic relations, the organization of work and the life of the urban working classes has thus begun. The workers sold their time spent in the factory instead of the finished product they had made. Horns, whistles, and bells announcing the beginning and end of shifts appeared in factories, and employees had to „clock in“ when arriving and leaving the factory. Time-measuring devices showing a synchronized time, timers controlled by factory sirens and control attendance clocks arise from the new industrial order. Uniform time is a symptom of modern times, industrial society - the phenomenon of attendance clocks, public time and synchronized time in transport carries the feature of modernity. The transition to synchronized time is associated with a certain transformation of the time perspective of modern man, the harmonization of society in the rhythm of three-shift operation. Stereotypes of controlled work behavior permeated all areas of urban life, and its rhythm became a reflection of the industrial operating standards of the factory enterprise. The city was thus becoming a factory of its own kind, interwoven with a web of clocks, ordinary home clocks, station clocks and public clocks on squares or

intersections, as well as clocks on gates or in plant halls, in public buildings and offices of all kinds, or signboard clocks on the walls of temples and finally, the old tower clock with a bell rivaling the factory siren.

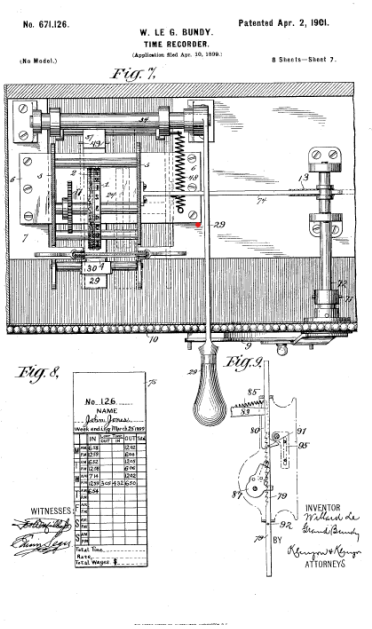

Fig. 1. Stamping mechanism of one of the first mass manufactured punch clocks invented by Willard Le Grand Bundy. Source: BUNDY, Willard Le Grand. Time-Recorder.United States.US Patent No. US671126. Apr. 2, 1901.

Economic Assistance Council (CMEA), the national company Elektročas produced and supplied clock networks, including attendance clocks, whose products penetrated pop culture films and general awareness not only in Czechoslovakia. Today, when time information has become commonly available thanks to DCF 77 radio-controlled timepieces, the Internet Network Time Protocol (NTP) or the Global Positioning System (GPS) navigation system, the classical uniform time systems have thus lost their monopoly on precise time. By the end of the 20th century, however, they were an indispensable part of modern industrial society.

2. Modern time as social consensus and technical artefact

2.1 Historical context - change in the way of measuring time in modern society - genesis of standard time

Traditional societies first naturally followed the „true solar time“, showing noon at a different time in each longitude . Later, when sundials and gnomons were replaced by the tower clocks of churches or town halls, time and its unity were determined by the horizon of walking distance. Later, true solar time was replaced by mean solar time, which was commonly used in larger local centers and was kept by mechanical timekeepers.

It was not until the beginning of the 19th century that the rhythm of the old world was disturbed by the incursion of regular stagecoach mail, which carried its own time. With the development of the railway, every train passenger and pocket watch owner could check for the presence of local time differences that they crossed while traveling by train. Thus, natural local times gradually began to be replaced by a uniform railway time, usually derived from an important railway junction or a dominant local center.

The train thus became another important driver of change in the organization of way of life and a carrier of modernity, even in a perspective of time itself. Historically, the first railway company in the world to introduce a common time for all stations was the British Great Western Railway in November 1840. By 1847, most railways in England were already using "London Time". That's why, in 1855, 98% of public clocks in Great Britain accepted this requirement and switched to standard time.

Standard time, however, was not enacted until 1880. The synchronized time is gradually being applied also in industry and in offices, and finally, thanks to worldwide time standardization, it becomes ubiquitous. The United States of America was the pioneer in introducing time zones. From November 18, 1883, tracks in the USA and Canada were divided into five time zones of 15° longitude, based on the time at the 60th meridian west of Greenwich. However New Zealand adopted the time zone fifteen years earlier. In the Czech lands and Austria-Hungary, time zones were introduced for railways and the postal and telegraph service on October 1, 1891, on the occasion of the introduction of a new railway timetable. Before that, "Prague time" was valid for a certain period of time in the Czech lands, according to the „ Prague meridian“ crossing the Old Town Square (2 minutes and 18-19 seconds behind Central European time)[1].

Railway time was therefore the first standardized time that began to operate in our territory. In 1891, Austria-Hungary introduced Central European Time for post offices and railways on 1 October 1891, which was adopted by major cities such as Prague and Budapest; Vienna did not join until April 1, 1893. The time indication thus definitively became a technical artefact, and the technical requirements for the distribution of the desired time information in public spaces, production facilities, offices and schools increased. The decisive influence on the development of modern time-measuring systems in the new order of artificial conventions of synchronized time was electricity and the almost simultaneous development of electric telegraphy[2].

[1]KŘÍŽEK,Marek. Železnice a Čas In: *Geografické rozhledy,* 2021-2022, vol 31, no 2, p. 18-21.

[2] Electricity was an excellent and practically the only functional means of spreading time information - a curious alternative to it was pneumatic systems, but they did not gain much traction

Clock networks were first used in the second half of the 19th century on the railways, later in industry and large administrative buildings at the turn of the 19th and 20th centuries. At the same time clock networks were installed on the decks of large ocean liners. Controlling many on-board clocks from a central point appeared particularly practical under conditions of a long-duration voyage where the ship crossed several time zones and it was desirable to coordinate the on-board time with the local time of the ports visited.[3]

2.2 The birth of time networks technology- the entry of electricity into the world of timepieces

In watchmaking, electricity was first used as a source of drive for winding the weights of mechanical clocks, later to move the pendulum or the flywheel. Already in 1830, the Italian physicist Zamboni constructed the first electric - electromechanical clock, the pendulum of which is attracted and repelled by two poles of the battery. In 1840, the English watchmaker Alexander Bain patents the first clock with an electromagnetic drive used in practice. It was equipped with a pendulum with a contact that switches the electric circuit and an electromagnet gives the pendulum an impulse. Already during the first experiments with the use of electricity in timekeeping systems, the first creators of electromechanical timepieces (M. Hipp, Austermann, Wheatstone, Steinheil) assured that such clocks are capable of distributing the time in public spaces very accurately. Another of their correctly anticipated advantages was their lower maintenance requirements, there is no need to wind them, there is no need to control the hands, and delaying or speeding up is practically impossible with these watches.

Although electricity and electronics will not fully dominate the world of timepieces until the second half of the 20th century, already a hundred years earlier electrical impulses were used to spread time information through electrical lines. One of the first public clock networks was installed as early as in 1851 at the World Exhibition in London by the excellent English watchmaker and inventor Charles Shepherd.

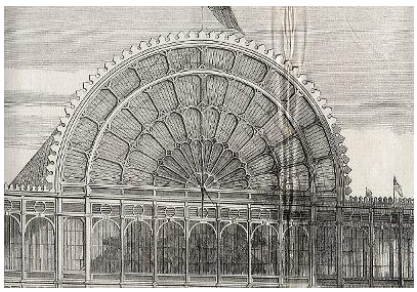

Fig. 2. The first public clock network made by Charles Shepperd at crystal palace in. Source: http://www.historische-eitmesser.de/biographien/shepherd-01.html

Electrical time transmission has historically been handled in three ways. Less accurate clocks are tied to more accurate clocks so that both pendulums swing synchronously, although not in the same phase, which is used, for example, in observatories.The second method represents the electrical connection of a certain number of secondary machines with the main clock so that the secondary machines are periodically regulated. This adjustment may mean simply moving the minute hand to the tenth minute, but a more perfect synchronization is possible, in which the clock is simultaneously automatically readjusted to the correct operation The third most widespread method is the connection of the main clock with secondary machines, which are practically adders of current pulses sent from the main clock

The first electromechanical clock networks of this kind was experimentally put into operation in 1839 at the University of Munich by the German physicist and astronomer Carl August von Steinheil. The main pendulum clock, located in his study, controlled a secondary clock in the university observatory two kilometers away via a two-wire telegraph line. Clock networks were built on this principle practically unchanged throughout Europe and the United States until the second half of the 20th century.

The secondary clock is connected to the main clock by a two-wire cable, into which the main clock transmits short, approx. 2 second electrical pulses. The polarity of these impulses changes alternately in both cabling lines every minute, which is why we speak of „polarized impulses“. Older types of main clocks (produced approx. until the end of the 1970s) were pendulum clocks with a classic mechanical drive and only electric winding or equipped with an electrically operated pendulum. Later electronic clocks controlled by a crystal oscillator were used as a source of minute impulses. However, the principle of the system is identical, i.e. the main clock is the source of time information, which it sends through the polarized impulses generated by it to the secondary clocks forming the end elements of the clock network.[4]

3.3 Unified „Elektročas“ - the birth of domestic technology of clock networks

Clock networks began to gain significant traction in Europe and the United States in the last decade of the 19th and the first decade of the 20th century. Since the beginning of the 20th century, Ludvík Hainz, a leading semi-industrial manufacturer of tower clocks in the Czech lands, was active as a supplier in the field of time systems, founded in 1936. At the beginning of the 20th century, Ludvík Hainz began supplying uniform time systems, first as an intermediary from a German company Böhmeyer, later produced them under license in his own operation in Prague's Holešovická

[3] The famous Titanic also had a clock network from the renowned Zurich company Magneta. The onboard clock of the clock network, showing the time of the sinking of the ship, is also a famous detail shown in James Cameron's Oscar-winning film. Source: https://www.encyclopedia-titanica.org/titanic-a-hypothesis-of-times-gone-wrong.html

[4] KŘÍŽEK, Marek. Železnice a Čas In: *Geografické rozhledy,* 2021-2022, vol 31, no 2, p. 18-21.

Tusarova street. From the Benzig company in Halle, Heinz imported clocks for checking attendance. The Siemens-Halske company also operated here, which had its own clock network technology distributed by Czech suppliers.

The American company International Business Machines (IBM), an important global producer of uniform time systems, established its branch in Žitná Street in Prague and supplied uniform time systems to many administrative buildings in particular, and was also successful in transport. The uniform time systems produced by it are based on a different technical principle than the competitive Elektrozeit/Normalzeit impulse system. The IBM system was three-wire and, unlike the competition, allowed for automatic adjustment of the exact time in secondary clocks. The disadvantage was that the system was under voltage the entire time it was running. The production, delivery, installation and service of the IBM system was provided by Jan Kulhavý's company, which serviced and operated these systems until the end of the war. After February 1948, these capacities were nationalized and later became part of the company Elektročas together with other producers of unified time. The third significant technological trace of the uniform time system leads to the company Ericsson, which was represented in the Czech lands by the electric counters factory from the Českomoravská-Kolben-Daněk (ČKD) portfolio.

However, the most important supplier of uniform time systems in pre-war Czechoslovakia was the firm Jednotný čas, established in 1923 with a forty percent capital contribution from the German company Elektrozeit and sixty percent of domestic capital.

4. From Jednotný čas in Elektročas

The Prague-based company Jednotný čas, based in prague quarter Karlín, did not produce uniform time components, but was fully dependent on its German co-owner, Elektrozeit, as a supplier. The latter supplied it with main and secondary clocks and other components of the unified time system. The company Jednotný čas had an exclusive contractual relationship with its German owner obliging it to purchase exclusively Elektrozeit products. In the 1930s, the Frankfurt company Elektrozeit merged with another German company, Telefonbau, and they created a new company called Telefonbau und Normalzeit, which produced telephone devices, signal technology and also uniform time systems, in line with the production program of its predecessor company, Elektrozeit. It was the dominant supplier of the unified time system in Germany, possessing a whole range of advanced technologies that it implemented in various areas of modern society. Its timekeeping division supplied sub-clocks, mother clocks, hourly clocks, switchboards, sirens and other components of uniform time, which it managed to apply not only in the transport industry, but also very successfully in public spaces, administrative buildings or in modern apartment buildings) .The company had a very developed branch network throughout Germany, and its subsidiary in Czechoslovakia, i.e. Jednotný čas, was built in a similar spirit, although without its own production capacities. Later, the company Normalzeit und Telefonbau supplied Jednotný čas with both secondary and main clocks, and the actual encapsulation was carried out in cooperation with Czech suppliers (the secondary clocks were encapsulated by the NAPAKO company). Technologically, and in terms of production, Jednotný čas was completely dependent on its German supplier.

Due to the established property relations, this relationship was mutually beneficial and enabled the use of the considerable production capacities of the German company Elektrozeit to satisfy the demand for uniform time systems in the territory of Czechoslovakia. Elektrozeit also made several special projects for large enterprises in Czechoslovakia, was the supplier of a time switchboard for the Czechoslovak Radio and also equipped Prague's Wilson station with its timing system, which even had a special telegraph system for automatic control of the main clocks in the individual station buildings of the state railway.

Jednotný čas came up with an original business model. It owned the time measuring devices installed at the customer for the entire period of their operation and provided them to users in the form of lease. Jednotný čas operated as a trading company fully dependent on the supply of products from the Elektrozeit company. Jednotný čas therefore had practically no production capacity and only had a network of service centers. A total of 7 branches in larger cities in Czechoslovakia.

However, at the end of the Second World War in 1944 the production capacity of the Normalzeit company was damaged by Allied bombing to the extent that it was no longer able to produce timepieces. The company Jednotný čas therefore improvised and started the production of its own timepieces according to the original German documentation and using spare parts. The company also received help from external corporations (for example, it outsourced the production of clockwork gear wheels and pinions to Switzerland). After the war, the company was nationalized and under national administration it soon became part of the national company Chronotechna. Company expanded after the next wave of nationalization in 1948 by taking over the production facilities of other important watch companies.[5]

They included the Hainz factory or the Jan Kulhavý company, which produced IBM clocks under license in our country, i.e. former competitors of Jednotný čas. When Elektročas was spun off from Chronotechna in 1953, it used the original German design and technology to start full-scale factory production of time-measuring devices of uniform time systems. It also took over the branch network of

[5] MARTÍNEK, Zdeněk. *Dějiny československého hodinářského průmyslu I a II.* Brno, [Nové Město nad Metují]: ELTON hodinářská, Technické muzeum, 2009. 245 s., obr. příl. (Studie z historie techniky a průmyslu ; 3) ISBN 978-80-7028-349-3

Jednotný čas service centers, which operated in large cities until privatization in the early 1990s.

The national enterprise Elektročas, later Pragotron, was formally established on February 10, 1953, as a spin-off from Chronotechna, whose clock networks division emerged from the merger of several pre-war enterprises. Elektročas, based for many years in Hloubětín in the building of the former pre-war Vitáček rye coffee factory at 22 Poděbradská street, later became a major European producer of timekeeping systems of the second half of the 20th century in the 1970s. It was a company capable of supplying clock networks systems - mother's clocks, secondary signal clocks and attendance „punch clocks“ not only for Czechoslovakia, but for 27 countries of the world, including the whole of Eastern Europe. After the agreement to end the competitive production of clock networks systems in the German Democratic Republic (GDR) under the Rundfunk - und Fernmelde - Technik (RFT) brand, Elektročas became practically a monopoly producer for the entire CMEA within the field. Together with Czechoslovak Tatra trams, Elektročas products are among the most iconic export products of socialist Czechoslovakia. The dominant design feature of the products, was minimalistic black and white clocks, but it also produced a number of secondary clocks with original shapes and colors, especially for interior use. The production portfolio of Elektročas also included mechanical and electric tower clocks, special timing systems (time standards), radio, television, the military, transport companies Czechoslovak state railways, Prague Metro or scientific workplaces and other special orders.

4.1. Transfer of technology - Technological heritage of the clock networks

However, the shaky beginning Elektročas company does not mean that this important European supplier would only rigidly persist in the pre-war heritage of its technological predecessors. By taking over the technically robust systems of the Normalzeit company it created a high-quality manufacturing and technological platform on which the company later built the independent development and production of especially advanced and at the time technologically progressive electronic timekeeping system, accelerated in the 60s. The triumph of Czechoslovak science and technology is one of the first types of practically applicable portable clocks controlled by a quartz oscillator Tranzistorové Křemenné Hodiny (TKH).

Fig.4. The First Czechoslovak quartz clock made by Elektročas company. Source: MICHAL,Stanislav. *Měření času a vývoj hodinářské výroby*. In: Sborník NTM.5. Praha 1968, p.101.

At the beginning of the 1960s, the national enterprise Elektročas became a partner of scientific workplaces, especially the Institute of Radio Technology and Electronics of the Academy of Sciences, with which it developed a whole series of special time measuring devices, time and frequency standards, and in 1984 the Temps device, an automated system for the distribution of unified accurate time information using the OMA transmitter signal in Liblice near Český Brod. In 1995, this transmitter was discontinued when it was displaced by the competing time signal of the DCF77 transmitter from Frankfurt am Main.

Fig 5 Comparison of the conformity of the design solution in the contemporary catalogs of the companies Elektročas and Normalzeit, 60s. Source: www.gvit.de,www.pragotron.sk

5. Conclusion

The technology of clock networks, the essence of which is the distribution of electrical impulses generated by the main clock has practically not changed since the end of the 19th century. The beginnings of time synchronization in Czechoslovakia are related to Jednotný čas company which started as a supplier of a German clock networks. Later after World War II it became its own company making copies of a German design and later its own systems. Due to the political influences the competing firms in Czechoslovakia were combined into one company Chronotechna, witch encompassed whole watchmaking industry in communist Czechoslovakia. Later decision of communist government to detach branch of Chronotechna, making clock networks (former Jednotný čas) made a new company called Elektročas, whom operates to this day. Classical clock networks were a kind of transitional evolutionary link in the development of timekeeping systems, they used precise mechanical clocks to determine the time, but time information is already being disseminated on an electrical basis. Clock networks controlled by polarized impulses were reliable timekeeping systems in public space, transport and industry for many years. The limiting factor for them was

the limited reach of the cable network and relatively high acquisition costs.[6]

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[6] They first tried to transmit accurate time information wirelessly in 1905 in the USA and Canada with the aim of checking the operation of precise marine chronometers. In Europe, around 1910, Germany and France began to transmit time wirelessly.

Source: MICHAL, Stanislav. *Měření času a vývoj hodinářské výroby*. In: Sborník NTM.5. Praha 1968.