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TRANSFER OF MASTER CLOCK NETWORK TECHNOLOGY TO CZECHOSLOVAKIA: ELEKTROČAS OR ELEKTROZEIT? GERMAN ROOTS OF CZECHOSLOVAK POST-WAR TIMEPIECES 1923–1990

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Abstract. Industrial production of timepieces began in the Czech lands as early as the end of the 19th century. Public systems providing coordinated time data (information) began to be successfully distributed on a larger scale in Czechoslovakia by the company *Jednotný čas* in the first third of the 20th century. After that, the company changed its name several times, especially from the 1950s, to *Elektročas/ZPA Pragotron*. The company produced clocks for both the public and industry as well as split-flap displays for transport. Almost all clocks at Czechoslovak railway stations, airports, public spaces, public buildings, and offices came from this company. The mentioned clocks (their mechanical parts) required a lot of maintenance, as other devices depended on their correct functioning, e.g. clocks recording the observance of working hours in enterprises (punchclocks). The process of forming the company is interesting not only from the point of view of the implementation of time into the public civic space, but also from the point of view of details, e.g. the technological transfer of timekeeping technology from Germany to Czechoslovakia during the 20th century. Specifically, the technology known as uniform time (master clock networks taken over from the German company *Elektrozeit* by the Czech enterprise *Elektročas*). The topic of the article is, therefore, the analysis of the process of adoption of this technology and its later use in the second half of the 20th century in socialist Czechoslovakia.

Keywords: History of technology, Czechoslovakia, technological transfer, timepieces industry, 20th century, centrally controlled economy, uniform time, master clock, master clock network technology, modernity.

1. Introduction – Elektročas phenomenon

Time is a long-term phenomenon affecting society, studied by many scientists, physiologists, psychologists, sociologists etc., but the concept of time still eludes historians in a certain way outside of the chronological context. Precise and internationally coordinated time information, which is so easily available today from a mobile phone or other commonly used digital device, was not easy to provide technically in the modern era of the late 19th and almost the entire 20th century. In public space, industry, education, and transport, it was still mediated by specific technical means at the end of the 20th century, i.e. extensive systems of centrally controlled, synchronised clocks, called unified time systems. Throughout the second half of the 20th century, they were essentially represented not only in Czechoslovakia, but also throughout Central and Eastern Europe by the products of the national enterprise *Elektročas*, continuing the tradition of its predecessor in the pre-war Czechoslovakia, the *Jednotný čas* company.

The indicators of the synchronised unified time – the black and white dials of secondary clocks produced by the *Elektročas* company – have become an emblematic phenomenon of many public buildings, railway stations, manufacturing companies, schools, and offices. Clocks placed in this way became part of Czechoslovak culture. Today, they are understood as important aesthetic elements of the second half of the 20th century. Their technological and visual starting point can be found in the German company, the predecessor of *Jednotný čas*. The timepieces produced by the *Jednotný čas* company before the World War II were a prototype for the technology, design, and visual identity of the uniform time clocks, which were later produced by the national enterprise[1] *Elektročas* under the *ZPA Pragotron* brand. Throughout the second half of the 20th century, the products of *Elektročas/ZPA Pragotron* were an omnipotential part of the multigenerational shared public space and its perception not only by the inhabitants of Czechoslovakia, but also by other countries, mostly members of the Council for Mutual Economic Assistance (CMEA), where the company supplied its products. It is less known that the design and construction of these timepieces were

[1]The term national enterprise was used to describe an economic unit in post-war Czechoslovakia. It is the official designation of state-owned enterprises, whose legal form arose from extensive nationalisation taking place in two waves. The first instance was brief, occurring in 1945 with the nationalisation of German property and large enterprises. The second instance was more extensive, occurring after the communist coup in 1948, when it affected virtually all economic assets in the country.

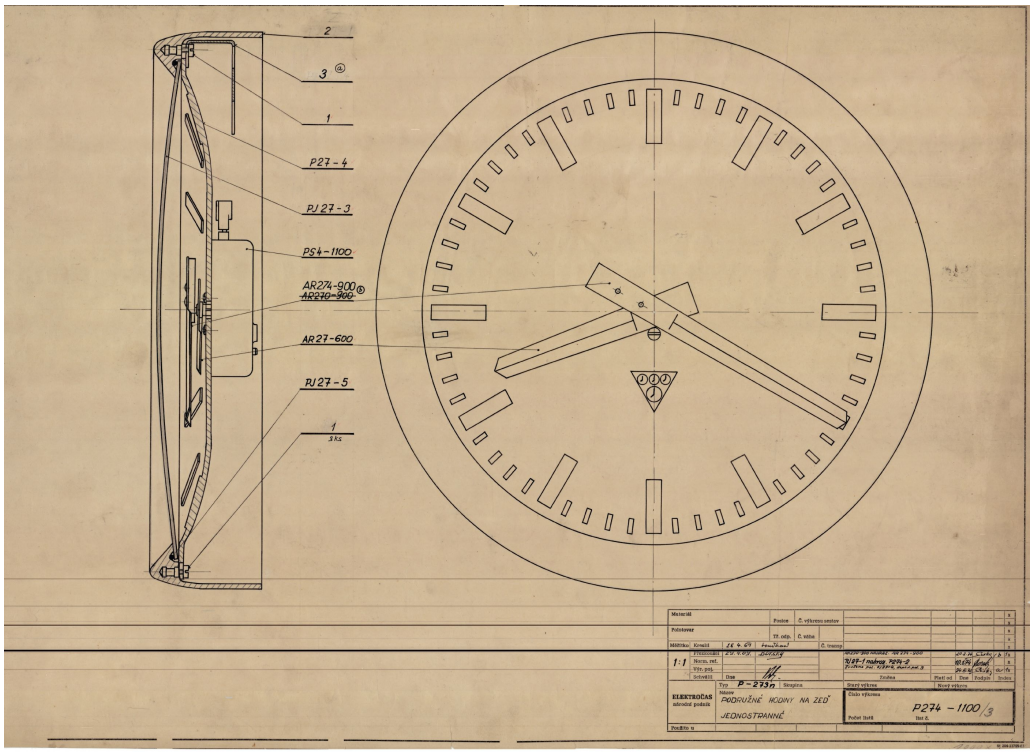

Figure 1. Blueprint of typical dial of Elektročas slave clock.

influenced by the pre-war clockmaking production of the German company *Elektrozeit/Normalzeit*. On certain examples of *Elektročas* products, up to the 1970s. (Figure 1), a direct line of inheritance leading up to the German model from the early 1930s can be conclusively documented and shown.

It is regrettable that the most significant sources for the study of the history of Czechoslovak watchmaking companies after the World War II are today the private corporate funds of successor companies, which typically do not permit researchers to access their sources.

The national enterprise *Elektročas*, later *ZPA Pragotron*, was established on 10 February 1953 by the state directed merger of several pre-war enterprises [1]. Specifically, the Czech branches of *IBM*, *Jednotný čas* and *Hainz*. The most important of them were the companies *Jednotný čas*, founded in July 1923, and *Ludvík Hainz*, a famous manufacturer of tower clocks since 1836, later also a producer of components for clock networks.

On 1 July 1963, all assets and liabilities of *Elektročas* were transferred to *Laboratorní přístroje* (Laboratory Instruments), a national enterprise headquartered in Prague. On 1 July 1968, the company was re-established under the same name *Elektročas* and at the same address. On 1 August 1969, the company was renamed to *ZPA Pragotron*, n.p. In the years 1973–1977, it advertised under the name *ZPA Pragotron*, n.p. – *Elektročas* (Praha 9, Poděbradská 22). It was then abolished on 1 January 1981, by the decision of the Minister of Electrotechnical Industry of Czechoslovakia. However, *ZPA Pragotron* was incorporated into the Závody průmyslové atomatizace (abbreviation ZPA) Čakovice group company and also performed under the name *ZPA Pragotron*.

The *Elektročas/ZPA Pragotron* timepiece company, based for many years in Prague quarter Hloubětín in the building of the former pre-war Vitáček coffee factory at Poděbradská Street No. 22, has always belonged to the important European producers of timekeeping systems of the second half of the 20$^{\text{th}}$ century. It was a company capable of supplying clock networks and its components, master clocks, secondary signal clocks and attendance clocks, punch clocks not only for Czechoslovakia, but for 27 countries of the world, mostly all of them in the Soviet sphere of influence, in the union of the Council for Mutual Economic Assistance (CMEA). After the agreement to end the competitive production in the GDR Kombinat *Rundfunk-und Fernsehtechnik* (under the RFT brand), *Elektročas* became a monopoly producer of the clock networks components for the entire CMEA sector[2].

The production portfolio of *Elektročas* included not only components of clock networks, master clocks, secondary attendance clocks and other additional elements of clock networks, but also solitary orders, mechanical and electrical tower clocks, special timekeeping devices (time standards) for scientific workplaces, radio, television, the army, the transport companies of

[2]According to Ing. Karel Prouza, who was a key employee of *Elektročas* in the 1980s and later the owner of the successor company *Elektročas/ZPA Pragotron* LTD, testified that up to 60 % of the company's production was exported to CMEA countries.

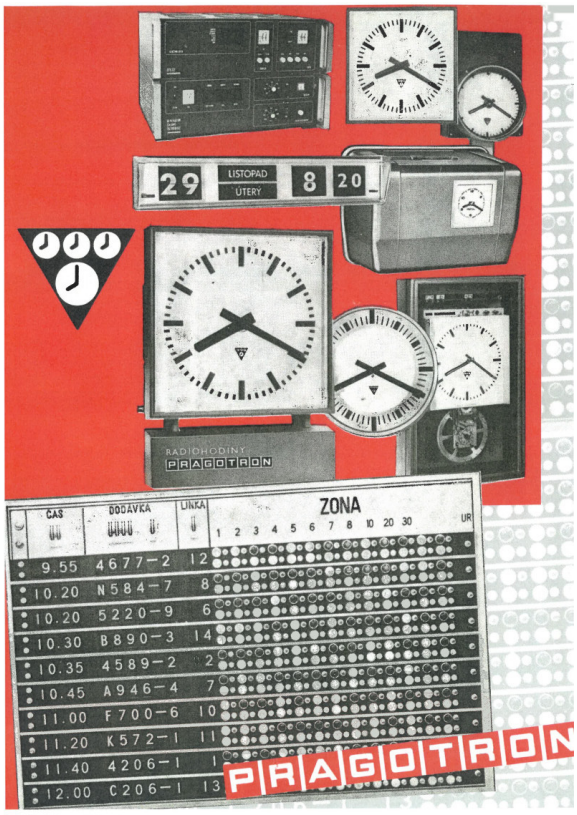

FIGURE 2. Presentation of product variety of Pragotron company.

the Czechoslovak State Railways (abbreviation ČSD), the Prague Metro, and, since the beginning of the 1970s, under the *ZPA Pragotron* brand, split-flap displays and information systems mainly for industry and transport showing warehouse management, departures of trains, and long-distance buses or airplane departures (Figure 2).

2. The technological and social nature of unified time

By the clock network, we mean a system of synchronised electric clocks that display centrally distributed time information in factories, public spaces, offices, schools, and railway stations. Clock networks became more prominent in Europe and the United States at the turn of the 19th and 20th centuries. The growing popularity of clock networks is mainly related to the transformation of the structure and organisation of urban and suburban societies, as well as the ways in which they began to structure, organise, and measure time. Information about the exact time gradually became independedetermination, local times gave way to more coordinated conventional times, controlled first from local centres (railway hubs), later valid nationwide.

The synchronisation of clocks in larger industrial areas, transport hubs, urban landscapes, and wider geographical areas gave rise to clock networks or uniform time systems. This phenomenon is one of the key features of a modern industrialised urban society, equipped with transport and engineering networks, highly time-aligned, requiring readily available time information from any place of its operation.

The central element of the entire system is always a source of time information, an accurate master clock or a central unit, which transmits a time signal in a regular, minute or half-minute rhythm via a cable by an electrical pulse to the peripherals, sub-clocks, which can be in the system from lower tens to several hundred. Secondary clocks are technically simple counters of electrical impulses. In addition to master and slave clocks, clock networks may include sources of sound signaling (school bells, sirens for signaling work shifts in factories), automatic lighting switching mechanisms, or, in industry, relay systems for turning off machines or other equipment, as well as control and record keeping systems of employee attendance, the once so popular attendance punch clocks. Although the functions of master clocks are today performed by electronic systems often controlled from a satellite (GPS) or a terrestrial radio signal (DCF), the systems of secondary clocks have practically remained unchanged in design. These end units of the system are still connected to each other by metallic wires and the time indicators continue to rely on the periphery of these systems to centrally distributed polarised impulses, which have been the principal foundation of clock networks since their first practical applications in the second half of the 19th century.

2.1. Traditional versus modern timekeeping and perception of temporality

In contrast to the highly organised, time-synchronised modern societies, traditional societies naturally followed the alternation of day and night and the resulting true solar time, showing noon at a different time in each longitude. The time perspective of traditional society was thus a world of isolated temporal monads of local times. However, with the development of the railway, suddenly, every train passenger and owner of a pocket watch could verify the presence of local time differences that he crossed on his train journey. Thus, the natural local times gradually began to be replaced by a railway time standard, usually derived from an important railway junction or a local centre [2].

Thus, time measuring devices began to be used in a somewhat different way than it was customary in traditional societies. The high demand for time synchronisation in transport, industry, and in offices – the transformation of the structure of the modern man's time organisation into leisure-rest and work time [3], the rhythmisation of working schedules in multi-shift operation, and the networking of urban and suburban companies with regular public transport led to an increase in demand for systems capable of keepinga uniform (de facto artificial) time in larger units, both geographically and organisationally. With

the development of transport, advanced industrialisation, and other changes brought about by modern times, time information itself has become a technical artefact to be secured, maintained and distributed by specific technical devices.

In the early days of time synchronisation, these were technically built on different principles, visual telegraphy was tried, the source of time synchronisation was acoustic signals (not only the sound of tower clocks but, for example, a cannon shot) [4, p. 102]. And a simple system of unified time – a mechanically linked time system is in a certain sense also the classical mechanical system of tower clocks – the four dials on the church tower – so if we consider the rod transmission from the machine to the dials as a system for distributing synchronous time information, then the master clock is the tower machine, and the set of dials the secondary ones. Wireless telegraphy and radio later created conditions for society to be effectively time-synchronised over a wider geographic area.

Figure 3. Slave clock produced by Jednotný čas company.

2.2. Electricity

From the middle of the 19$^{\mathbf{th}}$ century, mostly from the end until the end of the 20$^{\mathbf{th}}$ century, the key physical principle that was able to reliably ensure such a function, first in smaller more isolated systems and later in larger areas (urban landscape, transpfort networks, large industrial plants), was the electric impulse. It was the entry of electricity into the world of timepieces that enabled the efficient distribution of time information in clock networks. The first such transmission was experimentally put into operation in 1839 at the University of Munich by the German physicist and astronomer Carl August von Steinheil. The master pendulum clock, located in his study, controlled a slave clock in the university observatory two kilometers away via a two-wire telegraph line. Clock networks were built on this exact principle throughout Europe and the United States until the second half of the 20$^{\text{th}}$ century [5].

In horology, electricity was first used as a secondary, auxiliary element as a source of drive for winding the weights of wheel clocks and later as an agent to stimulate the pendulum, or the ballance wheel. Already in 1830 [6, p. 51], the Italian physicist Giuseppe Zamboni (1776–1846) constructed the first electric-electromechanical clock, the pendulum of which is attracted and repelled by two battery poles. In 1840, the English clockmaker Alexander Bain (1810–1877) patents the first clock with an electromagnetic drive used in practice. Although electricity and electronics would not completely dominate the world of timepieces until the second half of the 20$^{\text{th}}$ 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 1851 at the World Exhibition in London by the excellent English clockmakermaker and inventor Charles Shepherd (1829–1905) (Figure 3).

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 or subsidiary clocks with the master clock so that the secondary or subsidiary clocks are periodically (preferably every hour) regulated. The third most widespread way (and the one we are dealing with in this text) is the connection of the master clock with slave clocks, being in fact adders of current pulses sent from the master clock.

The slave clock is connected to the master clock by a two-wire cable, into which the masterclock transmits short electrical pulses in periodic minute or half-minute interval. The polarity of these impulses changes alternately in both lines every minute, which is why we refer to it as polarised impulses. Older types of master clocks (produced approx. until the end of the 1970s) were classic mechanical pendullum devices, only electricly winded or equipped with an electrically driven pendulum. Later, the clock networks were controlled by electronic master (quartz) clocks equipped with an electrically excited quartz crystal as an oscillator. However, the principle of the system is identical, the master clock is the source of time information, which it sends through the polarised impulses generated by it to the slave clocks forming the end elements of the clock network [6].

2.3. German technological influence on timekeeping technology in the Czech lands

The Czech lands have historically been under a strong German influence in terms of technology transfer, including the clockmaking industry. As early as the

Middle Ages, clockmakers settled in the Czech lands often came from German regions. The influence of the traditional clockmaking destinations of Augsburg and Nuremberg [7, p. 109] was particularly strong, but this does not mean that Czech clockmaking was not an autonomous, independently developing craft sector. The German influence, however, was not negligible both in the pre-industrial era and with the emerging industrialisation of the Czech lands. At the turn of the 19th and 20th centuries, two important branches of the German clockmaking companies Gustav Becker (1888–1930) in Broumov and Schenkler Kienzle (1887–1945) in Chomutov were established in Bohemia. These entities were behind the development of mass industrial production of timekeeping devices and to a large extent, saturated the common mass consumer demand for mechanical timepieces until the end of the 1940s.

Clock networks, which form a separate chapter from the technological point of view, did not arise in the Czech lands in an organic way, through an original independent development, but were massively adopted from abroad. For example, at the beginning of the 20th century, the city of Prague also demanded a reliable public street clock network [8]. The company Magneta through its representative, Mr. Jindřich Havlíček (1908), a Prague city clockmaker with ties to the city council, strove for a lucrative supply of an integrated centrally controlled system based on the principle of distributing polarised impulses from the master clock. However, the modern clock network from the Swiss company Magneta was only implemented in sample mode. A relatively strong lobby of Prague clockmakers made it impossible for this global company of Swiss origin with a number of branches in Britain and the United States to effectively penetrate the market of city orders, and the introduction of their technology through the implementation of public city time in Prague did not happen.

3. Entities (Subjects) participating in the introduction of uniform time technology in the Czech lands

The German influence was much more substantial and lasting, for example, the Siemens-Halske systems were gradually successfully established on the railways. Later, the Frankfurt- based company *Elektrozeit* competed with them through the *Jednotný čas* joint-venture.

Many domestic importers of clock network technology soon began to engage in the semi-industrial production of clock network components, secondary and master clocks, for customs reasons, mostly through the production of legally accepted designs, either under license or as branches of foreign companies.

Since the beginning of the 20th century, the company *Ludvík Hainz* (1836–1948), a leading semi-industrial manufacturer of tower clocks in the Czech lands, founded in 1836, was active in the field of time systems as a supplier. and intermediary from the German company *Böhmeyer*, later he produced them under a license in his own operation in Prague's Holešovická Tusarova street. From the *Benzig* company in Halle. *Hainz* imported clocks for checking attendance (punch clock). The Siemens-Halske company had its own master clock system distributed to the Czech lands by a domestic representative.

The American company *IBM*, an important global producer of master clock systems in the first half of 20th century, established its branch in Žitná Street in Prague and supplied clock networks to many administrative buildings in particular, and was also successful in transport industry (railways). The company *Jan Kulhavý* (1936) provided production, delivery, installation and servicing of the *IBM* system, which serviced and operated these systems until the end of the war. After February 1948, these capacities were nationalised and later became part of the *Elektročas* company together with other producers of unified time. The third important technological trace of the master clock systems introduced to pre-war Czechoslovakia leads to the company Ericsson, which was represented in the Czech lands and the factory for electric counters from the portfolio of the ČKD concern [1].

3.1. Company – Jednotný čas

However, the most important supplier of clock networks in pre-war Czechoslovakia was established in 1923 by the *Jednotný čas* company with a 40 % capital contribution from the German company *Elektrozeit* (later transformed into the *Telefonbau und Normalzeit* company through further mergers and asset transfers) and with 60 % domestic capital. *Jednotný čas* came up with an original business model. It owned the timekeping devices installed at the customer's premises for the entire period of their operation and provided them to users in the form of a lease. The *Jednotný čas* company functioned as a trading unit fully dependent on the supply of products from the *Elektrozeit/Normalzeit* company.

Jednotný čas company thus had practically no production capacity and only had a network of service centers. However, at the end of World War II in 1944, *Normalzeit's* production capacity 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 helped itself with external collaborations (for example, it outsourced the production of clockwork gear wheels and pinions to Switzerland). After the war, the company was nationalised and under national administration, it soon became part of the national enterprise *Chronotechna*, expanded after the next wave of nationalisation in 1948 by the production capacities

of other important companies producing timekeeping devices. They included *Hainz's* factory or *Jan Kulhavý's* company, which produced components of the clock networks under the *IBM* license, i.e. former competitors.

When *Elektročas* was separated from *Chronotechna* as an independent national enterprise in 1953, it used the original German design and technology to start full-scale factory production of time-measuring devices of clock networks. It also took over the branch network of *Jednotný čas* service centres, which operated in large cities until privatisation in the early 1990s.

3.2. Electročas and its use of adopted technology

Paradoxically, the Czechoslovak industry of timepieces production saw its most turbulent development just after the end of World War II, when Czechoslovakia fell into the sphere of Soviet influence. The transformation of the economic structure and society after the communist coup in 1948 was a fundamental change with a number of adverse effects on the national economy and the fate of millions of people, but it brought development to some specific branches of nationalised industry, for example industrial watchmaking [1].

The pre-war industrial production of timepieces in Czechoslovakia was mainly represented by the two large clockmaking companies mentioned above, the Broumov branch of the German company Gustav Becker (later Junghans), the Chomutov branch of the German company Schlenker-Kienzle, and a number of smaller entities producing clocks on a craft and semi-industrial scale. In the first half of the 20^{th} century, imports, mainly from Switzerland and Germany, played a significant role in the trade balance with timekeeping devices.

The Second World War brought a new dynamic to the Czechoslovak industrial production of mechanical timepieces and the introduction of wartime industrial fine-mechanical production on the former territory of Czechoslovakia (primarily in the border areas of Sudetenland, annexed by the Third Reich, where mechanical timers for anti-aircraft grenades (flaks) were produced in several larger production enterprises) and Protectorate of Bohemia and Moravia. The retention of the machinery of these factories on the territory of Czechoslovakia restored after the war, special machine tools in particular (known as long-turn automatic machines and gear cutting machines), together with the employment of key personnel capable of operating these machines played, inter alia, a crucial role in the later successful efforts to realise the independent production of mechanical wristwatches here and had a favorable impact on other sectors of the watchmaking industry, including the successful adoption of uniform time system technologies from German models and their adaptation to industrial mass production [1].

3.3. Continuity and time perspective of design solution conformity of adopted technology persistence

The Czechoslovak national enterprise *Chronotechna* and later *Elektročas*, which was separated from it, used mainly the technological heritage of the pre-war Jednotný čas company in the production of uniform time systems, whose products were based entirely on the design solution of the German *Elektrozeit* technology, while the attendance clocks were taken over from the pre-war heritage of the *Hainz* company, which used the design of the German company *Benzing*.

Each clock network is technically based on three structural elements: first, a master clock – the central source of time information, second, end time indicators, i.e. slave clocks on the periphery of the system, and third, a network that connects the centre and the periphery (wire repeaters, connecting elements). Until the 1980s, both the design of the master clocks and the machines and the design of the slave clocks produced by *Elektročas/ZPA Pragotron* were almost identical to the original German design solution from the early 1930s.

It it is noteworthy, however, that until the mid-1960s, master clocks produced by the West German company *Telefonbau und Normalzeit*, following on from their pre-war production by the company *Telefonbau und Normalzeit* (originally *Elektrozeit*), showed completely identical features to the product lines of the Czechoslovak *Elektročas* (i.e. the original German model). The vast majority of components were completely interchangeable, and the construction design of the timepieces was even visually identical, down to the smallest detail. Both companies, the original German *Elektrozeit* (Normazeit) and the Czechoslovak *Elektročas/ZPA Pragotron*, were very conservative in the design of the master and secondery clocks, the innovations that the machines underwent during the decades of mass production were more or less trivial in nature. This can be explained, inter alia, by the fact that the technical solution of uniform time systems (distribution of polarised pulses in minute intervals) as originally developed by *Elektrozeit* showed high reliability, structural robustness and was technologically completely sufficient for the needs of locations with uniform time until when classic mechanical pendulum clocks were replaced by more modern electronic systems (Quartz system) in the function of master clocks. Slave clocks designed for different voltages, but usually working in 12 V or 24 V mode, were often compatible with other systems (Siemens-Halske, Ericsson).

In terms of construction, the most widespread basic type of master clocks produced by *Elektročas*, manufactured for the longest time under the designation HH1, were classic pendulum clocks, the gear train and escapement of which are inserted between two brass base plates. A superstructure generating electrical impulses was placed behind the rear plate. The construction of the clock consists of a classic pendulum

FIGURE 4. Comparison of the technology and design heritage of Electrozeit in products of postwar Elektročas and Normalzeit companies.

movement with a graham escapement and a pendulum 0.75 m long, ensuring reliable operation of the clock, powered by a light 100 g weight, which is stretched at five-minute intervals by an electric motor. The weight twists the spring, which supplies the clock with constant energy so that there are no malfunctions during repeated stretching. The electromechanical clocks of this design remained in the portfolios of both companies until the end of the 1970s as solitary pendulum clocks – the master clock, the master signal clock, and the small clock control unit MUS 40. An essentially identical machine was produced until the 1970s by the company *Telefonbau und Normalzeit* according to the production documentation of its pre-war predecessor (Figure 4).

Elektročas also produced precise master clocks with an invar seconds pendulum, which they produced under the brand name HH3 or as part of the HUS 80 clock control units. These clocks were also structurally identical to the pre-war construction of the precise master clocks of the company *Telefonbau und Normalzeit*. Such clocks (still of the *Normalzeit* design) were equipped, for example, with the control unit of the Prague postal hedquaters in Jindřišská Street or the Czechoslovak Radio. The construction of the slave clock movement both in the *Elektročas* production and in the post-war company *Normalzeit* also maintained the continuity of the pre-war production.

4. Conclusion

The clock networks produced in Czechoslovakia throughout the second half of the 20$^{\text{th}}$ century under the *Elektročas* and later *ZPA Pragotron* brand were fully based on their pre-war German heritage in their basic constructions. However, we can also perceive the technology transfer of the master clock systems to Czechoslovakia in the broader temporal context of imports from nearby Germany, more advanced in the technology of time measurement caused by a sudden increased demand for reliable time synchronisation systems. The demand for the rapid introduction of clock networks of Czech society at the turn of the 19$^{\text{th}}$ and 20$^{\text{th}}$ centuries, solved by German imports, initiated the first attempts at domestic production of these technologies. The *Jednotný čas* company, as the most important supplier of these systems before the war and the protectorate period, then played a dominant role in the further and key transfer of technology to Czechoslovakia, which was taken over, developed, and industrialised by the *Chronotechna* company, later *Elektročas* and *ZPA Pragotron*. The original designs, which were reverse-engineered from the product portfolio of the *Jednotný čas* company in the early post-war period and later adapted for industrial production, formed the backbone of the industrial production of the clock networks for several decades under the banner of the company *Elektročas*. It is clear that the Czechoslovak industry of the timepieces production was capable of independent development and industrial production of the master clock networks, but it seemed functional to build on the proven and robust system taken over from the *Jednotný čas* company, whose technology was fully based on the pre-war production of the German *Elektrozeit* company. This process is nothing remarkable in the context of Czechoslovakian post-war economic and industrial history, and technological continuity with the pre-war heritage or foreign construction and industrial capacities can be found in number of branches of nationalised Czechoslovak industry. In the context of the time, it is not surprising that there were no attempts on the part of *Elektročas* and *ZPA Pragotron* for any financial or moral settlement of this silenced heritage, and the Czechoslovak industry thus benefited for decades from a technological profit that has its design roots in the early 20$^{\text{th}}$ century and is related to the German industrial and business influence.

The transfer of technology and knowledge is a phenomenon essentially linked to industrial history and the history of science and technology. The history of the dissemination of key scientific and technical knowledge is also the history of their acquisition by

breaking through legal barriers, industrial espionage, and copying patterns. In the end, the seeming controversies associated with the interpretation of the history of the Czechoslovak industry producing timepieces and the adoption of the technology of clock networks apparently do not represent any special case in the history of technology, but a common story as a whole, fragments of which are still part of the silent history of the Czechoslovak clockmaking industry.

Classical clock networks were a kind of transitional evolutionary link in the development of timekeeping systems. Accurate mechanical clocks were used to determine the time, but time information was already based on electricity. The clock networks controlled by polarised impulses were reliable timekeeping systems in public space, transport, and industry for many years.

Clock networks continue to be an important element of urban public space, are necessary time-orienting technologies in transport, and have not disappeared even from industrial buildings and administrative buildings. Their technological essence (distribution of time information from the centre to the periphery by means of an electrical impulse) remained practically unchanged from the middle of the 19$^{\text{th}}$ century, when these systems gained popularity, to the end of the 20$^{\text{th}}$ century.

After time information became commonly available in the late 1990s through DCF (Deutches/C-wave/Frankfurt) radio-controlled timekeepers, the Internet time protocol NTP (Network Time Protocol), or the GPS (Global Positioning System) navigation system, classical clock networks have lost their monopoly on precise time in modern industrial society. However, the products of the former *Elektročas/ZPA Pragotron* continue to form a characteristic visual element of many industrial buildings, public buildings, and railway stations not only on the territory of the former Czechoslovakia but also in a number of countries in Central and Eastern Europe.

Classic clock networks controlled from the central point, of the transport office, the director's office, or the control room of industrial operations, are today a kind of surviving reminder of the late modern era, gradually replaced by modern digital devices, involved in the globalised infosphere, instantly providing accurate and locally relevant time data, and domestic and global manufacturers of unified time systems have had to adapt to this trend. The era of the dominant position of *Elektročas* as a mass producer of public timepieces and its position as the exclusive supplier of the uniform time system for the CMEA countries is long gone. *Elektročas/ZPA Pragotron* disappeared in the early 1990s due to the loss of foreign markets and changes in economic conditions on the domestic market. *Elektročas* as a phenomenon is alive with the products of the successor company *Elektročas s.r.o.* and a growing fan base of admirers of the minimalistic industrial design of the black-and-white clock dials.

The products of *Elektročas*, which are still present in the public space today, with their design solution and thus also their hidden German pedigree, can, however, remind us of the variety and complexity of the processes of obtaining scientific and technical knowledge and adopting technology in the environment of Europe divided by the Iron Curtain.

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