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The Production and Distribution of Synchronized Time in Sweden, 1850–1914

Gustav Holmberg

What time is it? The answer, on a scale of seconds, at the turn of the twentieth century was provided by the combined workings of a heterogeneous system of technological artifacts and instruments, scientific knowledge, and experts in academic astronomical observatories and nautical schools, firms, state regulation, all forming a machinery for the definition, production, and distribution of precise time.

On the larger scale, railroads and telegraph systems were factors in the process of time standardization in many countries.[1] In the early modern period, each locality had its own local time, and it did not matter much that these differed within a country when it took days for a letter or a horse-drawn carriage to travel. The railroad and the telegraph changed this. Solutions differed. German railway timekeeping was initially especially complicated, with officials running the trains on five different times, while passengers kept to local time. In France, clocks inside stations had a special railway time (five minutes slow compared to Paris time), while clocks outside the station showed the local time, different at each particular city. Not to mention the challenges of the US railway system, with a difference of more than three and a half hours between the coasts. Many cities kept their own time, and traveling from Maine to California by train entailed changing the passenger's watch about twenty times.[2] There were reasons for the processes that saw nations standardize on a national time and, eventually, the whole world standardizing time to the Greenwich meridian. While the latter part of the nineteenth century saw the emergence of unified time zones on national and international scales, it is the more fine-grained synchronization of reality, on the order of seconds, that is the topic of this chapter.

Time was intimately coupled to nature. The rotation of the earth around its axis made the sun and the stars pass through the sky, and observing this passage defined the rotation of the earth and thus accurate time. Astronomers were the link between the rotation of the earth and time spread throughout society, they *produced* time.

The production and distribution of time can be seen as a public infrastructure of precision. Hannah Gay has noted that synchronized and precise time transformed from something that existed mostly within the walls of specialized astronomical observatories to something that was present throughout societies during the second part of the nineteenth century; synchronized time was vital for efficiency in workplaces and communication systems where an ethos of precision was a key part.[3] Time standardization became, in the words of Vanessa Ogle, "one of the major preoccupations of nation-states eager to cast a technocratic grid of time over national territory."[4] It was public and provided routines, signals, utilities for companies, citizens, organizations living the life of a modern society. It was also an infrastructure. Even if one might hesitate to add "infrastructuralism," as John Durham Peters has proposed, to the historian's collection of -isms, it is nevertheless possible to claim that infrastructures developed to such a degree during the nineteenth and twentieth centuries that in important ways they can be said to characterize the modern world.[5] Seeing these as emblematic parts of modernity, Paul N. Edwards has discussed the co-construction of infrastructures and modern societies. Infrastructures link macro-, meso- and microlevels of time, space and social organization, thereby providing a base for modern societies: "To be modern is to live within and by means of infrastructures, and therefore to inhabit, uneasily, the intersection of these multiple scales."[6] Time was such an infrastructure.

Edwards's multilevel perspective on infrastructures is evident in time synchronization in Sweden around 1900. The pedestrian on the streets of Stockholm gazing towards a public time signal in order to set the pocket watch to the correct time; national political processes giving a mean Swedish time and funding national standard organizations such as observatories and telegraphic networks; international conventions and conferences regulating time over global distances: all are examples of how time as an infrastructure works on various scales. It was an infrastructure built on precision. Experts played a central role, scientists handled these standardized technologies and produced time. It is to these scientists, especially astronomers, that we now turn.

Astronomers Producing Time

A newsreel from 1935 shows the Navigational School of Stockholm. The cameraman has zoomed in on the tower of this center of maritime expertise, and the twenty-five seconds of black-and-white footage shows a large metal ball hoisted to the top of a pole, silhouetted against the clear sky. Suddenly the ball drops. The camera pans over the surrounding cityscape and the waters of Riddarfjärden, where a ship is heading out to sea.[7] What the citizens of Stockholm—or at least those that cared enough about having correct time on their watches that they took to observe the Navigational School at the right time—witnessed was a time ball in action, signaling far and wide that the time was, at the moment the ball fell, 12.00.00 Greenwich Mean Time. It was an optical signal that allowed captains aboard ships moored in the nearby harbor to synchronize their clocks, thus securing proper navigation for the ships on the high seas—a method of determining position at sea hinged on having calibrated precise chronometers on board—and for civilian and modern urban life to be synchronized with high precision.

The prerequisite for dropping the time ball was to have precise time available locally, produced by way of astronomical techniques, and therefore such techniques and the standard-producing institutions that housed them is a part of this story. For a visitor to an astronomical observatory during the nineteenth century the flow of time was most audibly present; one could hear the time ticking away. Observatories had accurate clocks permanently mounted at the telescopes, and there were also portable chronometers that allowed the astronomers to move time about. The observatory was a milieu where time literally ticked away. "The clockwork mechanism with its conical pendulum works so silent and smoothly, with a soft sound making for a special atmosphere," as the physicist (and friend of August Strindberg) Vilhelm Carlheim-Gyllensköld articulated it in a fictional but fact-based short story about the experience of observing celestial objects during long nightly vigils at the Stockholm observatory, where he had worked as an assistant astronomer early on in his career.[8]

In principle the technology for producing precise time was straightforward. The astronomer observed standard stars with well-known positions as they passed through the meridian, that is, due south. In these observations of the star's passage through the meridian, a transit instrument was used, a telescope that was positioned in the north-south direction. The astronomer used a chronograph with a rotating drum that moved a paper tape in even speed over a pencil tip, forming a line on the paper. The pencil was hooked up to an electrical circuit coupled to the pendulum on a pendulum clock; at every beat of the pendulum the circuit closed, and the pencil made a small mark on the paper, forming a graphical representation of the seconds on the paper. The observer, placed at the eyepiece end of the transit telescope, observed the passage of the star through the meridian. In the field of view, a micrometer thread—often made out of spider's web—defined the meridian, and as the star passed it the observer pressed a button and an electrical switch coupled to the chronograph made a mark on the paper tape. Since the star's position was precisely known—it would pass due south at a time that was known in advance—an analysis of the marks made it possible to calibrate the mechanical clock against the ultimate time-reckoning device: the earth's rotation as mirrored in the stars gliding through the sky.

These clocks were in themselves important astronomical instruments, and a nontrivial part of astronomical technological development during the nineteenth century was constructing such clocks and keeping them well regulated, and several ways of eliminating inaccuracies because of temperature variations etc. were conceived.[9] Such observations were part of the standard practice at an astronomical observatory, often performed by an assistant astronomer.[10] Thus precise time was produced. But this time existed within the walls of the observatory only, and ways to move it out of the observatory were developed. Such a distribution of the time made the work of astronomers into something useful for non-astronomers, enhancing the role of the observatory as a standard-bearing institution in modern society. The production and distribution of precise time from observatories could be part of astronomy's contribution to colonial practices, of making and spreading a European order outside of Europe.[11] Sometimes such time distribution involved collaboration between state, academic, and commercial actors on local, regional, and national levels. In the United States where a multitude of such actors were active—universities such as Harvard where the observatory functioned as a standard-bearing institution, national academic standards organizations such as the US Naval Observatory, commercial companies in telegraphy, local astronomical observatories—all cooperated in a complicated way in spreading precise time.[12] British time standardization coupled a government-run institution of high standing, the Greenwich Observatory, with the surrounding society: clocks were transported by foot from the observatory to London's clockmakers, for them to synchronize their clocks; a publicly visible clock that showed the time was outside the observatory; time balls were mounted to send out optical time signals; and telegraphic time signals were sent out via the telegraph wires.[13] With these international examples as a background, let us look at time-standardization practices in Sweden.

Places for the Production of Time: Astronomical Observatories and Navigational Schools

Astronomical observatories at the Lund and Uppsala universities and the observatory of the Royal Academy of Sciences in Stockholm performed observations for the production of time. An accurate time was produced at observatories functioning as nodes in the networks of time regulation, by distributing time signals through time balls, telegraphic signals, and public clocks.

Figure 2.1 Public clocks were one of the technologies used for distributing synchronized time. They also symbolized, for the surrounding society, values of precision connected with science in general and astronomy in particular. This clock, at the gates of the Lund Observatory, was set up by Carl Charlier and synchronized by radio time signals from the Eiffel Tower and a transmitter at Norddeich, Germany. The citizens of Lund called it "rättaste klockan i Lund" (the most accurate clock in Lund). © Gustav Holmberg.

While astronomical observatories were time-producing standard-bearing institutions, another category of standard-bearing institution important for the chronometric network that made it possible to produce and distribute time appeared during the nineteenth century: the navigational schools. Founded as a result of a government decision in 1841, these schools were to provide training for personnel for Swedish merchant shipping.[14] They were located at the major seaports on the Swedish coast and enter this story as providers not only of trained personnel but also of precise time for the Swedish shipping industry. They were financed by the state and formed by state mandate, but there was also a local agency involved in their history; in several instances, leading political and commercial actors at the city level had an interest in and cared for the schools' well-being.[15] The navigational schools in Stockholm, Malmö, and Gothenburg, major port cities, are relevant for the history of time standardization and synchronization in Sweden. Here teachers taught astronomy, mathematics, and navigation; there were astronomical instruments such as transit instruments and refractors, as well as octants, sextants, artificial horizons and other astronomical and navigational equipment. They also had libraries stocked with relevant astronomical literature.[16]

In Gothenburg, the school had a transit instrument made by E. Jünger, a Copenhagen firm that produced scientific and nautical instruments for observatories, university laboratories, schools, and shipping companies. The transit instrument was permanently mounted in the school's observatory, and observations of standard stars with the instrument were used to regulate an astronomical pendulum clock with a mercury pendulum.[17] Similar observations were also performed at the Stockholm school.[18] Thus, the major navigational schools and astronomical observatories—at universities of Lund and Uppsala and the Royal Academy of Sciences in Stockholm—were producers of precise time. But what interests us here is not only the production but also the distribution of this time to non-astronomers. One was by way of telegraphy.

Telegraphic Time Signals

In the mid 1860s, "a special telegraph wire was installed, connecting the observatory to the Stockholm telegraph station."[19] The astronomical observatory of the Royal Academy of Sciences began in 1860 to exchange meteorological observations with the Paris observatory, and every day observations were sent to Paris, which functioned as a center, collecting such meteorological data from many European stations. Stockholm also got observations in return, and some of these could end up in Swedish daily newspapers. Data were initially sent by foot, the messenger walking to the telegraphic station, but soon it became evident that it would be better to send them directly from the observatory, thus the special wire.[20] The Stockholm observatory became connected to an infrastructure of data handling that tied together the local—what was the weather like on Observatory hill in Stockholm at a certain time?—with a transnational Pan-European level with France as a leading nation. The astronomer Urbain Jean-Joseph Le Verrier had suggested to Napoleon III that the country should organize an international telegraphic network for the exchange of meteorological data, and such a network came into existence during the latter part of the 1850s.[21]

Further on, the observatory began to use this telegraphic connection for time standardization purposes. It transmitted regular time signals to the telegraphic central station and to the national naval base in Karlskrona. These signals were sent to stations in Sundsvall, Gothenburg, and Malmö, and from these main stations time signals were further distributed to stations in cities connected to them.[22] In the early twentieth century, the number of connected stations included Luleå, Umeå, Härnösand, Sundsvall, Norrköping, Stockholm, Gävle, Kalmar, Malmö, Halmstad, Gothenburg, Karlstad, and Örebro.[23] Signals were sent each Monday at 08:20:00 Central European Time and were preceded by a warning signal. The receiving station became, one can surmise, a node in a local network of precision providing people passing through the station with the possibility to calibrate their pocket watches. The reliability is difficult to judge, but suffice it to say, it did not always work properly: one source remarks that the "signal is sent from the Stockholm observatory, but is sometimes lost along the way."[24] Keeping the functionality up was a nontrivial task, but nonetheless the combination of astronomical observations at one of the leading observatories in the country and the telegraph network gave a time-synchronizing effect on a national scale. A grid of precise time was laid over the country.

Time Balls

Time signals also came in an optical version: time balls, which were installed in many countries from 1829 and onwards, often in close proximity to harbors, used for calibrating chronometers aboard ship for navigational purposes.[25] This maritime connection also occurred in Sweden. The Navigational School in Stockholm mounted a time ball on its roof soon after its founding. It became a beacon of time in Stockholm, signaling Stockholm mean solar time "to the second," as a newspaper notice put it in 1849.[26] To this was added a time ball over the Stockholm cityscape when the observatory of the Royal Academy of Sciences began such a service in the winter of 1860.[27]

In Gothenburg, home to much of Swedish shipping exports and imports, the Navigational School had a time ball, initially in use three times per week: Tuesdays, Thursdays, and Saturdays. The financing and organization of the time ball service in Gothenburg shows the combination of the Swedish state and local actors. Both local and national actors cared for the installation and maintenance of chronological infrastructure. In Gothenburg, the installation was funded by a grant from local businessman Gustaf Lindström, a philanthropist who had made his money producing tobacco products and donated substantially to social issues in the city of Gothenburg.[28] The maintenance and running of the time ball service cost 600 riksdaler yearly, paid by the state on a grant applied for by the city's Commercial society (Handelsförening).[29]

By 1914, there were time balls in Stockholm, Karlskrona, Malmö, and Gothenburg, all dropping the ball at 13.00.00 Swedish Mean Time, signaling that it was 12.00.00 Greenwich time. The time ball was hoisted some minutes before this, and when it dropped, ships' crews could calibrate chronometers aboard ship. In Stockholm, the ball was at the Navigational School, in

Karlskrona by the military wharf, in Malmö by the harbor's pier, and in Gothenburg at the Navigational School.[30]

Time balls were of use for the shipping industry, but also became a fixture in the skyline of the city; they were observed by people other than ship captains. "Unfailing like destiny, the time ball is active every day at 1 o'clock over the roof of the navigational school. Then Stockholmers stands with watch in hand, eyes gazing towards the height to compare and adjust one's personal watch in accordance with the time ball."[31] Time balls also became something of a metaphor, as when a journalist described the collapse of a twenty-meter high chimney as a sublime spectacle with "the certainty of a time ball," or when another journalist describing a sunset wrote that the sun "set like a golden time ball" on the horizon.[32] In a somewhat flowery language a journalist described how not only watchmakers but also many others interested in time waited in anticipation of the fall of the time ball at the roof of the Navigational school in Stockholm, "a daily decree that each and every one of us must follow."[33]

In 1912, the daily newspaper *Aftonbladet* ran a large article on modern pocket watches that discussed how to best keep one's personal watch calibrated, in which it was pointed out that it was important to compare the watch not just with any public clock "but instead with a public clock that was controlled by an observatory, otherwise one might think that there is a difference in time, that does not exist in reality."[34] In the same issue of *Aftonbladet*, there is also an article about a company that delivers time controlled by an astronomical observatory: Swedish Normal Time, Inc. (Aktiebolaget Svensk Normaltid, more on it in the next section), "a modern, practical and reliable organization," of utility for people in a society where time is money.[35]

One feature of infrastructures is that they are discussed publicly when there are glitches, disturbances, or outright failure. And the same is true for the time service by time balls. When the Navigational School in Stockholm in connection with a change in staffing decreased the days of the week with service in 1866, complaints were voiced since then the ships' officers could not synchronize the ships' clocks often enough.[36] When the time balls stopped working—for a variety of reasons, such as a failing motor, or when heavy blasting because of construction work close to the school disrupted the precise astronomical observations—people complained, and journalists reported on it.[37]

Time in the Cityscape: Swedish Normal Time, Inc.

So, the time balls were of use for merchant shipping, for clock makers, and also for ordinary citizens minding their lives with watch in pocket, navigating urban modernity. Gazing towards a dropping time ball once a day was supplanted by another way of distributing synchronized and precise time signals throughout the cityscape, a technology that provided a steady stream of precise and observatory-controlled time throughout the day, not only once a day. It was provided by a collaboration between a private company and a professional observatory: Aktiebolaget Svensk Normaltid—Swedish Normal Time, Inc.—appears on the time-standardization scene in Sweden at the turn of the century. While the state, scientific expertise, and standards-setting bodies are active in the creation of the infrastructures of modernity, companies could also play a role. Aktiebolaget Svensk Normaltid was founded in 1901 by John Andersson, an engineer who worked in telephony and telegraphy, as well as in the development and installation of lightning rods by the thousands, a successful engineering business that won him prizes at exhibitions in Stockholm 1897 and Paris 1900 and also commercial success, eventually making it possible for Andersson to donate substantial funds for a professorship in lightning research at Uppsala University. Andersson's company was influenced by systems of time synchronization already installed in the United States, Germany, Finland, and Denmark.[38] Customers subscribed to the company's time service in the form of clocks. The clocks were connected to the ultimate arbiter of turn-of-the-century timekeeping—the sky—through a network that contained astronomical instruments and professional astronomers at the observatory of the Royal Academy of Sciences, the Swedish telegraph system, as well as Swedish Normal Time, Inc. A clock placed by the company in the Stockholm observatory was calibrated by the astronomers by way of observations with transit instruments. From the observatory, time signals were sent by telegraph wires to the central station of Aktiebolaget Svensk Normaltid in central Stockholm, regulating a master clock, and secondary clocks throughout the city where regulated from the master clock via telegraph wires to march in synchronicity. In their advertisements, the company emphasized that the clocks displayed Swedish standard time, that they were automatically synchronized via time signals from a central clock and, furthermore, that they were automatically winding up; precise and synchronized time without fuss was the product.[39]

Thus, the combination of astronomers, the telegraphy grid, and Aktiebolaget Svensk Normaltid meant that a precisely calibrated and synchronized time became available in public spaces such as railway stations, shops, banks, etc. One example was the new and large central post office inaugurated in Stockholm in 1903; it contained about seventy-five clocks in various places throughout the large and modern building, synchronized from Aktiebolaget Svensk Normaltid. In the commemorative publication hailing the post office building as a modern working environment serving a vital communication technology, it was pointed out that the large building had access to precise time from the Royal Astronomical Observatory.[40]

Aktiebolaget Svensk Normaltid sold a time service, quality guaranteed through astronomy and the Royal Academy of Science's observatory. In its publications it pointed out the value of the service for modern life; their "electrical clocks, regulated in full with a normal clock at the Stockholm observatory, play a large and practical role in general life."[41]

Time Synchronization by Radio

Time balls and synchronization by telegraphic networks were eventually supplanted with wireless technologies. Signals, thus, could be used for calibrating ships' chronometers at sea, far away from the time balls in the harbors. Some years into the new century, most larger passenger ships crossing the Atlantic were equipped with morse telegraphy equipment. From 1905, time signals were sent by radio from the US Hydrographic Office, in 1907 the Marconi Wireless Telegraph Company sent out signals from a station in Halifax, Nova Scotia, and by 1910 two powerful transmitters, one in Norddeich by the German Baltic coast and another in the Eiffel Tower, distributed time signals reaching large parts of the Atlantic ocean and the landmasses surrounding it. The grid of time synchrony, earlier tied to visual closeness to time balls or by actual wire hookup, spread further to places not within sight of time balls or outside of the telegraphic system.

The first three stations sent signals at specified whole hours according to Greenwich time, while the French station sent signals according to mean Paris time. Having used that convention for slightly more than a year, the Eiffel station on July 1, 1911 switched over to sending telegraphic time signals that were "the mean time of Paris, retarded 9 minutes and 21 seconds," that is Greenwich time.[42] The French had to accept the emerging practice and convention of transmitting in Greenwich time, but this unpleasantness (for the French) was partly compensated when politicians and scientists took an initiative that aimed at placing Paris at the center of a Pan-European system for the production and distribution of standardized time signals.

The Bureau des Longitudes therefore wanted to gather official delegates to an international conference on the topic of time signaling by radio.[43] This involved diplomacy and national prestige: should Greenwich or Paris take center stage; should the treaty text even mention Paris explicitly or not, keeping open the possibility that the International Geodetic Institute (in Berlin) would take over as host for such a time service; could the French state really guarantee access to the privately owned Eiffel tower in the future?[44]

The French state, on the initiative of its Bureau des Longitudes, thus convened an international conference to discuss time standardization via radio, with the aim of forming a future international time service. The conference met for one week in October 1912 and a second time the year after, with representatives from sixteen countries.[45] The Swedish part of the conference entailed a collaboration between scientific expertise and public administration.[46] The Ministry of Education and Ecclesiastical Affairs sought the advice of the Nautical-Meteorological Bureau, the Royal Academy of Sciences, and the chancellor of the nation's universities, who, in turn, collected the opinion of the mathematical-scientific sections of the philosophical faculties of Uppsala and Lund Universities. The result of this deliberation was that the state appointed the astronomer and Lund University professor Carl Charlier to be Sweden's delegate at the conference.[47] At the conference in October 1912, a provisional committee for an international commission on time was inaugurated, charged with planning the next conference in 1913. At the second conference, also with Charlier as Sweden's delegate, an international convention for an international time organization was put in place, and the task to organize such a bureau was given to the Paris observatory.[48] Charlier could not sign for Sweden, but to the proceedings he added that Sweden's government had an interest in this international convention for providing time signals and intended to later ratify and join. This also happened in January 1914. Sweden was now part of "an international collaboration with the task of providing unity to time signaling in various countries through the transmission of radiotelegraphic signals, useful for scientific uses of time with high precision, as well as for the demands posed by navigation, meteorology, seismology, railways, postal service and telegraphy and so on."[49] Sweden had agreed to a yearly payment of eight hundred francs and also to provide a delegate in the permanent board of the organization, a post for which Charlier was intended. This decision had been the result of deliberations between the minister of education and ecclesiastical affairs and the Royal Academy of Sciences through its members Magnus Nyrén, Karl Bohlin, and Vilhelm Carlheim-Gyllensköld. Charlier already had plans for the Lund Observatory, where a receiving station for these signals was to be installed, paid for by Lund University.[50]

In the process of Swedish participation in the international organization for producing and distributing precise time signals via radio there was a collaboration between the public administration and the Royal Academy of Sciences. While the foreign office and ministry of education and ecclesiastical affairs handled the matter in a formal sense, the Royal Academy of Sciences was an important advisory body, acting as a representative for the country's scientific expertise, choosing a suitable expert, the astronomer Charlier, to help the state in these matters of standardization of time on an international level. This collaboration was rather close, with Charlier meeting with the foreign minister and the minister for education and ecclesiastical affairs for verbal reports of the work in Paris.[51]

Charlier, being an astronomer, had ample expertise in matters of time determination and standardization. He was also at the time working in a field that demanded time synchronization on an international scale. Charlier's intention was to expand astronomy by adding seismology to the domain of astronomy. The emerging field of seismology was not yet fixed in the taxonomy of disciplines, and Charlier thought that it should belong to astronomy, one argument being that knowledge of the interior of the earth would help the studies of other planets. Representatives of other disciplines thought otherwise, and in the faculty at Lund the physicist Albert Victor Bäcklund argued that it belonged to meteorology and the geographer Hans Hugold von Schwerin instead wanted to place seismology in physical geography. Charlier came out as a (partial) victor in this academic turf war: in 1912, the Parliament provided funding for mounting a seismograph at the Lund observatory.[52] Measurement of seismographic signals had a use for precise and globally synchronized time, and thus the work in Paris suited Charlier's local interests in Lund. Also his part of the proceedings in Paris meant that Sweden had a representative that knew the technicalities of time synchronization, and that he could play a part providing scientific expertise to the state, something he also did in other areas such as the implementation of statistical methods in areas such as demography, pension schemes, and railway economy. Charlier was—and perceived himself—as a society-oriented astronomer, providing scientific expertise for societal uses.[53]

Thus, Sweden in January 1914 became part of an organization providing precise time signals via radio telegraphy. Soon, however, European countries had other and more dire things to handle, and finalizing the international collaborations on time signals via radio had to wait until after the war. One outcome, though, was strengthening the use of the Greenwich meridian for international time reckoning.[54] After the war, organizing such activities fell under the domain of IAU, the International Astronomical Union, and its commission.[55]

But that is another story. As is the story of the emergence of the atomic clock in the mid-twentieth century, keeping time more accurately than both astronomical observations and the rotation of the earth, whose rate of rotation is variable for various geophysical reasons. Time is now produced in a laboratory rather than an observatory.

Acknowledgments

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NOTES

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15. See for example "Navigationsskolans ifrågasatta nybyggnad," *Svenska Dagbladet*, October 25, 1904.
16. Series such as *Astronomische Nachrichten*, *Astronomisches Jahrbuch*, the *Nautical Almanac* as well as textbooks in astronomy by John Herschel and William Huggins, for example, were acquired. Yearly reports of the Navigational School in Gothenburg 1847–77, Sjöbefälsskolan i Göteborg B2:1, Regional State Archives in Gothenburg.
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