
[NOTE: The subtitle with the plural "Zeitordnungen", as it appears on the jacket, is correct. The singular "Zeitordnung" on the title page stems from a printer's error.]

This book has two main subjects: the invention of the mechanical clock and the effects of that invention on society and consciousness in medieval and early modern Europe from the thirteenth century until the advent of the industrial revolution. It is manifestly based on a massive and systematic effort to comb the archives and libraries of European cities for previously unknown or poorly digested information (see, e.g., the list of sources on pp. 355-58). Bound though such an effort is never to be complete, in this case it has resulted in a quantum leap in our knowledge about one of the more important subjects in the history of science and technology.

The book consists of ten chapters varying in length from about ten to seventy pages, with each chapter subdivided into clearly labeled sections of between one and ten pages. The two most substantial chapters, four and eight, are devoted to the two central subjects of the book: the invention of the mechanical clock and the spread of measuring time by equal hours through various sectors of social activity. There are seventy black-and-white illustrations. All of them are directly and clearly related to points made on adjacent pages, many of them have never been published in this context, and some of them have never been published at all. There are about eighty pages of endnotes with supporting documentation. Usually they are limited to references to specific pages in the relevant secondary literature and published as well as unpublished primary sources. Every now and then there are direct quotations of some length and excursions into details of the secondary literature for the purpose of clarifying conflicting views or refuting erroneous assertions. More often there is no text in addition to the reference, or merely the briefest characterization of a reference as especially illuminating, authoritative, or misleading. Following the notes are five pages listing the most important titles in the secondary literature. The book concludes with a list of the sources from which the illustrations were taken and a four-page index of names, places, and a few major subject entries.

The first chapter contains an introduction in which the author defines his subject matter and establishes his position with regard to the existing secondary literature. Having briefly elaborated on the significance of the mechanical measuring and social awareness of time in general, he describes at greater length writings about the clock from the middle ages to the present. Among the most important modern contributors to the received wisdom about mechanical clocks he identifies well-known social theorists like Marx, Weber, Sombart, and Mumford along with historians like Bloch, Yves Renouard, and Jacques Le Goff, as well as the standard authority on the history of the hour so far, Gustav Bilfinger. He shows that in consequence of their views the appearance of mechanical clocks is commonly identified with a shift from an organic to a mechanical awareness of time that is largely attributed to the leading role of merchants and thought to signal a profound process of social modernization. The
typical reference is to Jacques Le Goff's distinction between church time and merchant time. Dohrn-van Rossum's central contention is that the simplified assertions derived from this literature are, in their simplicity, mistaken. He sets out to improve our knowledge by a systematic review of the available primary sources.

Chapters two and three form a prelude to the main parts of the book. Here the author reviews and clarifies the state of our knowledge about ancient and medieval methods and instruments of time-keeping until the arrival of the mechanical clock. He deals briefly with the sundials and water clocks of antiquity, but spends most of his attention on a careful description of the medieval division of the day into twelve hours of the day and twelve of the night whose length depended on a combination of the season and geographic latitude. He pays special attention to the relationship between canonical hours and hours of the day, explaining their respective functions and the most likely explanations for the differences between them. In an especially important section he describes monastic time-keeping and its defining characteristics: important is the sequence of events beginning at a particular moment in time (Easter for the yearly, vigils for the daily cycle), not the length of each event. He insists on the need for distinguishing clearly between mechanisms for waking at a particular time, measuring time in equal units, and striking bells. On that basis he rejects Mumford's and Weber's characterizations of monastic time-keeping as mechanical or rationalistic and disengages monastic time-keeping convincingly from the method of measuring time in units of identical length.

Chapter four, the longest in the book, is devoted to the invention of the mechanical clock. Reviewing and in many instances correcting received views, Dohrn-van Rossum distinguishes between two main issues: the invention of the escapement and the combination of escapement-based clocks with hour-striking mechanisms. The former was by far the more important. It was the escapement which made it possible for the first time to measure time reliably and consistently in units of equal length. The latter required at bottom nothing more than the idea to combine a revolutionary instrument with another mechanism that was developed independently, to some extent perhaps modeled on older bell-striking machines, and in itself by no means crucial to the introduction of modern time-keeping. Nonetheless, and curiously enough, there is no record for the invention of the former, whereas the latter immediately attracted enough attention from contemporaries to have left a useful deposit in the sources. Thus it is impossible to tell who invented the mechanical clock and where or to what extent the invention was modeled on Chinese precedents.

In the body of the chapter the author analyzes these issues in detail. He shows how escapements worked and how to distinguish between different kinds of clocks. He surveys the evidence for legendary inventors and describes the varieties of instruments and methods of time-keeping prior to the invention of the escapement: horologia (standard equipment in the monasteries by the 13th century), water-clocks, astrolabes, and particularly famous individual clocks. He analyzes Needham's claims for Chinese precedents and surveys the evidence surrounding the invention of the escapement. The most important sections are devoted to early bell-striking machines, the invention of the escapement, the sensa-
tion caused in the 1330s by the appearance of mechanical clocks that were able to strike the appropriate number of bells at the appropriate hour, and the various ways of dividing the day into equal hours that emerged at the time: the Italian hour, counting twenty-four hours from nightfall to nightfall; the "Nuremberg hour", dividing day and night into anywhere from 8 to 16 hours depending on the season; and the "half hour", dividing the twenty-four hour day into two equal halves consisting of twelve hours each and beginning at midnight and noon. The chapter concludes with a brief section on the nearly simultaneous introduction of the hourglass. The author is careful to point to the difference between water clocks and hourglasses, and to insist on the novelty of the latter.

Chapter five marks the transition from the story of the invention of the mechanical clock to Dohrn-van Rossum's second main subject: the clock's impact on society. From this point on the author goes well beyond correcting received opinions by offering a wealth of genuinely new material. The subject of this chapter is the manner in which the new clocks spread throughout Europe. The author begins by reconsidering the standard interpretations from Bilfinger to Le Goff, defining "public clocks", and reviewing the instances in which public clocks are first mentioned. He then distinguishes several phases in, and motives for, their diffusion in the fourteenth century. He is careful to stress that whatever social utility clocks may have acquired later on is unlikely to have functioned as a major motive in their initial diffusion. Demonstrable is the role of monarchs and princes who insisted on installing public clocks, sometimes against the resistance of merchants unwilling to pay the cost. More important were the initiatives of cities not wishing to lose face in the competition for urban prestige with other cities already equipped with clocks. And finally, since the early fifteenth century, it became common for governments urban and otherwise to require the introduction of clocks in their territories by administrative decree. The chapter concludes with a carefully balanced statistical analysis of the spread of clocks along temporal and spatial lines in the fourteenth century.

The main results of this analysis are that public clocks were introduced in northern Italy early in the fourteenth century, spread unevenly for about two generations, experienced a genuine boom in the 1370s, and had by the end of the fourteenth century become a standard piece of public equipment for any self-respecting city. It is thus true that the spread of clocks is inextricably connected to towns and cities, but there is considerable evidence that this was due to other factors than any special role played by merchants, and no evidence that it was. It is true as well that the introduction of clocks is related to urban modernization, but is best understood as part of a larger process including many other parts (e.g., schooling, mills, engineers, and fiscal administration) which proceeded according to their own logic and were by no means necessarily related to the introduction of clocks.

Chapter six is devoted to a survey of clock makers in the late middle ages. It appears that there was no single group or craft of clock makers but that the required skills were distributed over a considerable variety of social groups none of whose members drew their income exclusively from clock making. Until the invention of the mechanical clock clock makers are predominantly found in a monastic environment. Thereafter the picture changes. The most famous clock
makers of the fourteenth century were university-trained scholars, astronomers, and physicians, among whom Abbot Richard of Wallingford, Jacopo and Giovanni Dondi, and the Parisian physician Jean Fusoris may be mentioned. Another group consisted of government-employed engineers otherwise busy with making buildings, weapons, mills, or musical instruments. Similarly widely-traveled was a group of mechanics who specialized in the expensive business of making and repairing public clocks. By far the largest number of clock makers, however—well over half of the known total—was drawn from among smiths and locksmiths.

Chapter seven deals with the role of the mechanical clock in organizing the public space of the city as a whole. The ensemble of urban signaling equipment was based on the city tower and the city bell but extended to a large number of other bells used for clerical and civic purposes. Dohrn-van Rossum highlights the significance of the city bell as an instrument of city government and describes the detailed and increasingly complex urban regulations designed to prevent the confusion arising from the proliferation of bells rung for widely different purposes and groups of people: prayer, funerals, visiting dignitaries, closing the gates, beginning the market, calling assemblies, beginning and ending work. For purposes of illustration he describes in some detail how bells were actually used in three cities: Tournai, Treviso, and Venice. He shows that by the early fourteenth century the profusion of bells had resulted in a day-long jamming of the airwaves comparable to the jamming of a limited electromagnetic spectrum by the profusion of radio stations in recent times. The introduction of the mechanical clock thus made it possible to replace an increasingly bewildering variety of bell signals by means of appointed times fixed in a single frame of temporal reference that was signaled by a single or several coordinated bells.

Chapter eight is the second longest in the book. Here the author turns from the role of the clock for the city as a whole to its role in various subsets of social activity, and here he offers a detailed account of the emergence and effects of measuring and scheduling time by modern hours of identical length. He begins by using the evidence of chroniclers and especially notaries to argue that the earliest uses of modern hours did in fact overlap with the appearance of the clock but that reckoning by the modern hour was nonetheless used only sporadically for some considerable time before it became normal practice. Resuming the question of Le Goff's distinction between merchant time and church time, he shows that merchants surely used the modern reckoning of time and did so early on, but not in any way to justify placing them in the forefront of temporal innovation, while clerics and clerical institutions, far from offering resistance, adopted the modern methods like everybody else, and sometimes earlier than anybody else. Le Goff's distinction thus turns out to be a misrepresentation unless its suggestive force is taken for nothing more than the call for further research as which it was mainly intended and as which it has here been taken by an author who is careful to pay proper respect to Le Goff.

Having disposed of this issue, Dohrn-van Rossum uses the remainder of the chapter to discuss the most important areas in which the modern hour made its appearance from the fifteenth to the eighteenth century. Beginning with a general discussion of the uses of modern hours in urban schedules as exemplified by the
well-documented case of Cologne, he goes on to focus his attention on four limited areas of social activity where the sources reveal scheduling to have played an especially prominent part: the meetings of urban bodies, markets, schools, and sermons. The reasons why these activities began to be scheduled according to the modern hour are different in every case. Urban bodies such as city councils, courts of law, guilds, and parlements had increasingly complex administrative or jurisdictional responsibilities and required the participation of increasingly specialized personnel participating in many different sorts of public and private activities. Here the main goals were to assure punctuality and efficiency. In the context of markets, on the other hand, times were usually scheduled in order to place limits on competition and protect the interests of townsfolk, often by establishing different schedules for citizens, non-citizens, and the various types of producers, traders, and middlemen offering and purchasing wares. In schools and universities hourly schedules offered an eminently practicable means of coordinating the study of different subjects in a curriculum, ranking their importance according to the amount of time to be spent on them, and determining the appropriate fees to be paid to the instructors. These goals had been much harder to realize as long as they were defined in terms of books to be mastered. Finally, innumerable early modern ecclesiastical ordinances, first among Protestants—Christian liberty notwithstanding—then among Catholics, used reckoning by the hour to impose limits and schedules on all sorts of churchly activities: services, baptisms, marriages, funerals, catechetical instruction, and especially the preaching of sermons. Here the main motives were, on the one hand, to limit excesses of doctrinal exuberance on the part of overly enthusiastic preachers and, on the other, to safeguard the participation of audiences hampered by a limited attention span and preoccupied with the business of their lives. With the single exception of papally mandated sermons to convert the Jews, regulations were always used to establish maximum rather than minimum times.

The upshot of the great volume of new and detailed information that is offered on these pages is threefold. First, the author shows the great variety of different uses to which the new measurement of time was put in different contexts. "The organization of time" was no single act or series of acts consciously effected by any ruling group, but an anonymous process of modernization composed of many individual strands each with their own rationality. Only in hindsight can these strands be related to each other and centered on the appearance of the clock. Properly speaking the expression "the organization of time" is thus appropriate only for each individual strand, such as the development of academic schedules. Second, two equally important but quite different aspects of the new ordering of time can be distinguished: establishing fixed points in time by means of mechanical clocks and measuring allotted amounts of time by means of the hourglass. Third, the author identifies an underlying reason for the introduction of time scheduling: it furnished a means of control that was perhaps not ideal (desirable goals could surely be defined more clearly in terms of substance than in terms of the length of time during which such goals were to be pursued), but whose "mechanical" disadvantages were more than outweighed by the ease with which it could be applied. Infractions of rules about specified amounts of time to be devoted to specified activities were far more easily identified and compared.
with each other than infractions of rules about the quality of an activity. That made their enforcement both "more just" and less susceptible to dispute.

Having made these central points, the author concludes the chapter with a look at two especially entertaining areas of social activity: torture and science. The new measurement of time was enthusiastically used to establish and rank different degrees of torture. But contrary, perhaps, to the expectation and, certainly, to the widely held view that science must have been in the forefront of temporal innovation, the mechanical measurement of time turns out to have played a minimal role in science until the scientific revolution of the seventeenth century and the invention of more precise clocks in the eighteenth. The prominence of the modern measurement of time in an activity of such obvious importance for social order as torture and its late appearance in the realm of science add further weight to the author's contention that the advantages of the new measurement of time for purposes of control and enforcement were a central factor in their spread. It also reinforces his view that—with all due respect to Thorndike, Mumford, and Crombie—the arrival of the mechanical clock is not to be confused with the arrival of scientific rationality. Until the early nineteenth century life according to the clock had little to do with any concept of "physical time" but remained more or less synonymous with life under an urban government.

In chapter nine the author turns to the significance of the new measurement of time for the regulation of work. His central point here is that until the eighteenth century the day remained the most important and fundamental temporal unit in which amounts of work were measured. Measuring and paying labor by the hour was rare except in cases of work beyond normal limits and failure to appear for work. At the same time the new measurement of time had a significant impact on the organization of work well before the appearance of factories and industrialization. This was mainly because here as in previously discussed contexts precisely fixed schedules made it easier to formulate and enforce compromises between the conflicting interests of workers, employers, and the members of different crafts and guilds. In the late middle ages it already became apparent that canonical hours were too uncertain a means of measuring time to allow for effective conflict resolutions. Bells were introduced to indicate the beginning and end of the workday as well as the times allotted for breaks in different rhythms for different occupations. With the introduction of the clock it became possible to fix those times with increasing precision, gradually to replace different bells for different areas of work by reference to the urban clock, and to place more clearly identifiable limits on the amount of work expected by employers. In this fashion the measurement of time had gained a prominent place in the regulation of work well before industrialization. What is true is that with the spread of factories, factory clocks, and privately owned watches since the eighteenth century the monopoly of the urban clock was broken while conflicts over work time began to center on control over the factory bell. The chapter concludes with a few brief observations about early forms of the obsessively detailed form of temporal planning known as Taylorism.

Chapter ten is designed to bring the story of the medieval and early modern introduction of the clock to a conclusion by identifying the markers distinguish-
ing time-keeping in the nineteenth and twentieth centuries from earlier forms. Dohrn-van Rossum shows that the mechanical clock did profoundly change the structure and function of medieval time-keeping but, only in part because of technical difficulties, did not displace its fundamental parameters. Until the early nineteenth century these continued to be the extent of a single day, from morning to nightfall, and the space of a single city. To be sure, the new measurement of time figured prominently in the organization of long distance communications. Dohrn-van Rossum shows this at length in a detailed discussion of postal services and communication speeds, from Asian precedents via the use of messengers to the establishment of a postal monopoly by the family of Taxis in the Empire. Here the obvious interest in speed and the desire properly to reward high speed encouraged the use of the modern measurement of time to fix arrival and departure times as well as to assess the length of transmission times with precision. As early as the fifteenth centuries the use of the hour was well established in this context. Governments and postal companies used the new measurement of time systematically in order to achieve increasingly high and precisely fixed speeds throughout the early modern period. Nonetheless the preponderance of "urban monads" in the structuring of time was not brought to an end until the introduction of the railway. It was the railway which brought about a genuine revolution in the speed of transport and communications and it was the railway which for the first time linked towns in a solid transregional network. It was only now that nation- and continent-wide schedules provoked the appearance of national time, and it was only the adoption of Greenwich mean time in the late nineteenth century which established a single temporal framework for international communications. Dohrn-van Rossum's history, in other words, confirms once again the profound importance of the industrial revolution in breaking with the past. The book ends with a few sentences about universal time and the invention of the atom-clock, slyly inviting the reader to succumb to the temptation to speculate on inter-galactic time-keeping in the society of the future and thus to part company with the author in more ways than one.

There are many different ways in which this book increases our knowledge. In some cases Dohrn-van Rossum offers the first sustained and reliable treatment of specific issues, such as his quantitative analysis of the diffusion of clocks through Europe in the fourteenth and early fifteenth centuries, based on close to five hundred pieces of information about the first appearance of clocks in identifiable locations from 1300 to 1450 (pp. 152-63), and his prosopographical study of clock makers in the later middle ages, more than doubling the number of identifiable clock makers to a total of about 1200 (pp. 164-84). This allows for a number of new insights. Dohrn-van Rossum can show that the speed of the clock's diffusion is comparable to that of modern innovations, dispelling myths about the slow pace of medieval compared to modern history. By identifying the different occupations of late medieval clock makers he disposes of the belief that clock making was carried forward by members of a single craft or guild with a well-defined social role who might otherwise be imagined to have functioned as the prototype of modern engineers. He demonstrates convincingly the overriding importance of the city as a fundamental social unit—and the length of a single-day as its temporal corollary—down to the early nineteenth century. And in fo-
cusing on the nearly simultaneous emergence of the clock and the hourglass as the most important instruments of keeping time he is able not only to dispel the myth of the supposed antiquity of the hourglass but also to relate the appearance of both to underlying social changes.

In other cases Dohrn-van Rossum exposes the apocryphal nature of familiar stories that have often been credited with the status of primary evidence and used to undergird misleading accounts. Noteworthy among them are the belief that King Charles V of France issued an ordinance making the new reckoning by the hour mandatory (pp. 202-204), the supposed twelfth-century clock maker guild of Cologne (pp. 95-97), and the identification of master Henlein with the inventor of the pocket watch known as the "Nuernberger Ei" (pp. 118-20). In other cases he is able to draw on his comprehensive knowledge of the evidence to expose misinterpretations in the secondary literature. Telling cases are A. C. Crombie's belief that time reckoning by minutes became important in the later middle ages (pp. 260-61); the confusion between the mechanical clock and the hour-striking clock (p. 348 n. 180); and the confusion of Dondi's astrarium with a church clock (p. 124 and p. 353 n. 5). The number of similar improvements on the existing secondary literature is too large to detail, but a sampling of the following endnotes will enlighten the curious: pp. 330 n. 13, 333 n. 9, 340 n. 95, 342 nn. 109 and 113, 347 n. 165, 349 n. 189, 367 n. 29, 373 n. 31, 391 n. 36, 398 n. 30.

Above all else, however, Dohrn-van Rossum has thoroughly reshaped the history of the clock and time-keeping. In spite of the respect with which he treats previous views as epitomized by Le Goff's emblematic distinction between church time and merchant time, there is no doubt that his account renders those views obsolete. In the central chapters of the book he has broken entirely new ground. Where there used to be a plausible but schematic thesis, there is now a detailed and very different story that has never been told before, throwing bright light on such different phenomena in the history of European society and technology as the organization of torture and the ringing of bells, painting a kaleidoscopic picture of the uses of clocks and time in late medieval and early modern Europe, and creating a vivid image of some of the most salient aspects of life in European cities before the industrial revolution. What stands out in the reader's memory are the exuberant profusion of bells ringing all day for all sorts of purposes before the appearance of the clock, the excitement about the new machine, the desire of towns and princes to have the best and biggest clocks, the sheer variety and complexity of late medieval and early modern social life, the thoroughness with which the effects of the clock spread into the nooks and crannies of that life, the faint weight of the distinction between clerics and merchants, the fundamental importance of cities in defining the social space of late medieval and early modern Europe, and the anonymous logic of a process of modernization in which the clock played a major part.

At the same time Dohrn-van Rossum wears his learning lightly. If it is evident that his book is founded on massive research, it is evident as well that the evidence supporting his results is marshaled without pedantry and only as far as necessary to make a point. Clearly a great deal more could have been said, and doubtless was said in the "Habilitationsschrift" of which this book is a
condensation. Anyone who has ever attempted to draw a complete picture of anything on the basis of medieval sources will appreciate the unpretentious brevity with which major results are here presented as if it had not taken years to compile them (see, e.g., the list of dates about the spread of the clock on p. 362 n. 90). The author writes refreshingly unacademic German, clear and to the point. He eschews polite qualifications in favor of firm judgments, leaving no doubt in the reader's mind about his reasons for holding a given view to be wrong or misleading. He defines his terms with exemplary clarity and distinguishes wherever distinctions are needed, making it unexpectedly easy for the reader to follow an argument about the complicated effects of a complicated piece of technical equipment. Above all else, however, the author resists the temptation to engage in extended arguments. Firm in his conviction that the distinctive merits of his case rest on fresh evidence, he is content to present the evidence in a manner that persuades by its clarity and detail rather than the author's personal intervention. Understatement is the most pervasive quality of this book.

That may make it difficult for the uninitiated to appreciate the novelty of Dohrn-van Rossum's account. And there are points at which it may conflict with the interest of scholars wishing to retrieve the sources on which it is based, for example, in the bibliography and the index. Given the great amount of primary and secondary sources that have here been systematically evaluated and updated, future research would surely have benefited from a complete list of the primary and secondary sources cited in the notes. The concise list of the most important titles which is currently furnished on pp. 403-407 seems addressed at an audience with little patience. And given the great number of occasions on which specific pieces of information are strategically placed to illuminate a broader subject, it would surely have helped to have a more detailed index.

On the other hand, however, the author's preference for understatement is perhaps the quality most likely to assure this book a long life and a larger audience than is common for books founded on massive scholarly efforts. Here is a story that is largely new and attractive to readers extending from clockophiles, via academic historians, sociologists, and anthropologists of many different stripes and colors to anyone with a serious interest in the impact of technology on society. Here is also a story that is unlikely to change for many years to come, either in its main outline or in its substance, because of the author's determined effort to let the sources speak as much as possible for themselves and to refrain from explicating his reasoning except where absolutely necessary, and then briefly. That a great deal of reasoning has in fact gone into the shaping of the story is evident to any careful reader, but it is deployed with unusual economy. Anyone with a vested interest in the subject and perhaps a desire to tell a somewhat different story will therefore think twice before attacking positions so well defended by powerful weapons and so likely to be supplied with more ammunition than has here been put on display. I would be surprised if this book does not become the standard authority on its subject for a generation of scholarship. I would be surprised as well if it does not generate a considerable amount of new research on the many different strands in the history of the clock...
and the measurement of time that Dohrn-van Rossum has been the first to identify.

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