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Clocks and Time in Edo Japan

Frumer, Yulia

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CLOCKS AND TIME IN EDO JAPAN

Yulia Frumer

A DISSERTATION

PRESENTED TO THE FACULTY

OF PRINCETON UNIVERSITY

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Abstract

The use of clocks for timekeeping seems to be a straightforward and almost intuitive routine. Glancing at mechanical clocks designed in Edo period Japan, however, we witness how modern-day intuitions betray our attempts to understand devices created in a culture remote from us in both time and space. These timepieces, odd to modern eyes, emerged when European timekeeping technology arrived in Japan in the sixteenth century, and was reinterpreted by Japanese clockmakers according to their own assumptions about time, their habits of handling non-mechanical timepieces, and visual conventions. Unraveling the array of underlying habits and assumptions embedded in Japanese clocks, we realize that these habits shaped the meanings of timekeeping, caused variations in those meanings among different users, and were responsible for the series of changes in timekeeping practices, concepts and technology.

The lesson we learn from Edo clocks is not limited to Japanese history alone. The changes in Japanese timekeeping suggest that the modern notion of time is not intuitive but rather rooted in Western habits of thought and practice. These habits were partially reproduced by Japanese astronomers through Western astronomical calculation methods, and unearthed by the nineteenth century lay Japanese users of Western watches who tried to make sense of Western devices they initially deemed bizarre and nonsensical. Seeing this process of reconstruction of Western timekeeping conventions, we discover that it was the gradual shifting of underlying habits of timekeeping that paved the way to the eventual adoption of the Western timekeeping system in the beginning of the Meiji period.

The investigation of Japanese clocks allows for broader conclusions. It suggests that any foreign technology or system of knowledge is necessarily understood through the existing arsenal of underlying habits, assumptions and conventions; and that social and structural change, such as reforms in timekeeping system, can only be effective when underlying habits come to support them.

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Introduction

What About Japanese Clocks?

Hunting for exotic curiosities at local markets, Western visitors to Meiji Japan[1] encountered some particularly strange objects. Obviously mechanical, they were nevertheless marked with Japanese characters, and even though one could guess that these were, perhaps, a kind of a measuring device, it was not always clear what were they supposed to measure. Some of them resembled Western clocks, but others looked more like some sort of device to measure length or height. Surprisingly, the price of these devices was comparatively low, indicating that there was perhaps not much demand for them on the Japanese market. Westerners bought these native objects to serve as an elegant piece of furniture exhibiting "oriental" qualities — lacquered wood, gilded ornamented panels and exotic characters. In the beginning of the twentieth century, European collectors put these objects on public exhibition, even inviting Japanese Embassy officials to come and share their knowledge of these wondrous objects. But to the collectors' great amazement, the Japanese in Europe claimed that they had never seen such objects before and were very surprised to discover that they came from Japan.[2]

These objects were Japanese clocks. Born out of the encounter between European timekeeping technology and Japanese practices, they were highly valued throughout the Edo period but made obsolete by the calendrical reform of 1873, which adopted the Western calendar, Western methods of timekeeping, and Western clocks. In the beginning of the twentieth century, according to one of the European collectors "Japan has become largely denuded of these

[1] Meiji Period (1868-1912).
[2] Drummond Robertson, *The evolution of clockwork* (London: Cassell, 1931), p. 194.

interesting objects; and even the cultivated Japanese (*sic.*) appear to be ignorant of the existence of these relics of pre-revolution days."[3]

What were the forces behind this birth, rise and eventual demise of Edo-period[4] mechanical clocks? How did Japanese clockmakers decide what to do with the newly imported mechanical technology and how did these decisions bring about the emergence of designs that barely resemble Western prototypes? What were the conceptual elements that influenced the transformation in attitude towards timepieces, timekeeping and time itself? And what can we learn from these clocks about the nature of temporal practices in general?

These questions target topics in the history of Edo period Japan, yet the answers have implications that go beyond the field of Japanese history. One striking advantage that practices and technologies of non-Western cultures provide us with is their capacity to uncover and unmask elements we tend to take for granted. Alternative approaches illuminate historical and social factors, as well as cultural currents we are not even aware of. Japanese timepieces and the related timekeeping practices tell us even more — their designs and uses point out that there is nothing natural, inherently logical, or pre-determined about temporal systems, and that the development of timekeeping practices, both in the West and in Japan, was contingent upon the cultural context. Even though we no longer accept early twentieth century collectors' explanations about a "unique Japanese character,"[5] we still desire to find some kind of rationale behind the design of Japanese timepieces, and explain it by reference to social structures or specific everyday needs. Yet these valuable explanations also conceal one essential feature of

[3] Drummond Robertson, *The evolution of clockwork*, p. 191.
[4] Edo Period (1600-1868).
[5] Unsurprisingly, Drummond Robertson cites *The Book of Tea* by Okakura Kakuzo from 1919, which was one of the major works that propagated the idea of Japanese uniqueness in the West. Drummond Robertson, *The evolution of clockwork*, p. 192.

human actions — that sometimes we do things in certain way because we were educated to do so, because our previous knowledge implies this course of action — because it is a convention.

The word "convention" is often associated with the social realm, and has a rather negative connotation. "Conventions" are thought to be the enemy of novelty, creativity, originality and progressiveness; they are deemed to be irrational and disconnected from reality; they are considered to be the contrary of everything we value. But is it really so? Do conventions only pose obstacles to creativity, or, perhaps, they are the very core of human practice? When we talk about conventions, we usually think of broad and obvious structures; but these overarching structures, which usually remain unchanged throughout long periods of history, create a framework for innumerous minor conventional practices that are often implicit, tacit, and seemingly insignificant. These patterns of practice might also be defined as conventions — they are carried out almost intuitively and rarely challenged — but just because they are so numerous, and just because humans constantly update their repertoire of these practices, they constitute a creative basis for every activity.

Japanese clocks show us the prevalence of such conventional, habitual patterns not only in the social, normative constructs but also in handling and developing of technology, in ways people look at objects, decipher visual information, in the very way people learn new methods and approach the world. This project focuses on the various uses of conventions, established patterns of practice and tacit assumptions involved in timekeeping in Edo period Japan. These include habits of time reckoning and its uses, established approaches to handling timepieces and looking at them, tacit assumptions concerning images of time, and ways to interpret timekeeping technology. These patterns and assumptions were neither random nor completely detached from social structures and practical needs, and many of them did represent rationality of some sort, but

this rationality was not necessarily rooted in the existing conditions of Edo period, and was not necessarily even meaningful to contemporaneous social and conceptual structures. Yet conventional patterns still determined the way people held a timepiece in their hands, delineated the range of possible things one could do with timekeeping technology, and even dictated what people saw when they looked at the face of the clock. Consequently, when we examine the incorporation of Western timekeeping technology into the Edo-period temporal landscape we ought to take into account the existing patterns of practice and tacit assumptions that shaped the very approach to foreign technology and concepts.

The purpose of this study, however, is not only to analyze the initial reception of Western technology, but also to explain the gradual change in its conceptualization and the subsequent abandonment of the hybrid technology of Japanese clocks in favor of Western timekeeping conventions. If reception of foreign technology and forms of knowledge was shaped by the preexisting patterns of practice and information analysis, then what caused these patterns to change? The answer lies in the multiplicity of these patterns and the constant choices people made, deciding which ones out of the whole repertoire of possible patterns of practice were applicable to any particular case. Clockmakers chose to employ the traditional association of hours with cardinal directions in their placement of the midnight hour at the bottom of the dial; astronomers chose to disregard the everyday conventions, but were conscious of trigonometric calculations when they measured time; and those interested in navigation incorporated geographical space into the sphere of relevance of the notion of time. The history of Japanese clocks, therefore, can be seen as a gradual rearrangement of the sphere that encompassed patterns of practice and tacit assumptions relevant and applicable to timekeeping and the notion of time itself.

Themes and Problems

Modern Time

It is not uncommon for our evaluation of the past to be shaped by our view of the present. Looking backwards from the perspective of present-day technological advances, we often tend to disregard how great castles were built and rivers shifted. And when we find ourselves alarmed by growing mechanical alienation, we tend to feel nostalgic for pre-industrial times. In a sense, our relation to the past is often similar to the relation to an "other." In the same way that past generations of Westerners used to romanticize and mystify "the orient," "we moderns," Westerners and non-Westerners alike, sometimes tend to attribute to pre-modern men all the qualities we think we no longer possess.

The discourse surrounding the nature of time certainly did not escape this tendency, and one easily find a long series of past/present dichotomies, born out of the attempt to define our own, modern time. One of the earliest dichotomies we find is that between the "linear" nature of Western and modern time, which can be chronologically arranged and quantified, and the past perception of "cyclical" time. Since the "cyclical" perception supposedly preceded the linear one,[6] it is deemed primitive and lacking historical consciousness.[7] Although this specific dichotomy no longer occupies a dominant position in academic discussions, it did not simply vanish but was rather transformed into yet another dichotomy; namely, the one that juxtaposes the modern urban lifestyle to the lives of people in past, agrarian societies. The proponents of this dichotomy claim that in pre-modern societies people lived according to the "natural cycles"

[6] See G. J. Whitrow, *The Nature of time* (New York: Holt, Rinehart and Winston, 1973, c1972), 35.
[7] On modern historical consciousness see for example Reinhart Koselleck, *Futures Past: On the Semantics of Historical Time*, Keith Tribe, trans. (Cambridge, MA: MIT Press, 1985).

of the sun and the moon,[8] and that their time had a "concrete" meaning, in the sense of having specific qualities such as being sacred or profane, or prone to the influence of ghosts and harmful humors. Certain scholars of time maintain that pre-modern time was perceived not in terms of temporal units but as the relative duration of human activities, namely as "the time it took to do X."[9] This is then contrasted to the "empty" and abstract time of modernity,[10] governed not by human needs but by man-made mechanical clocks.[11] Finally, all these attributes are said to characterize societies that have not yet reached the capitalist mode of production, and have not yet formulated the principle that "time equals money."[12] It appears that those thinkers who seek to analyze and criticize modern capitalist time as abstract and alienated find it necessary to define its "other", namely pre-modern time, as natural, organic, mythical and free from the tyranny of the ruling class.

In Japanese historiography, too, the image of the Edo period temporal order is often influenced by literature that focuses on the later, Meiji period, and stresses the new, Western-style time management that emerged in the mid-nineteenth century.[13] The authors of these works

[8] E.P Thompson, "Time, Work-Discipline and Industrial Capitalism," in *Past and Present*, vol. 38 (December 1967), p. 60.

[9] E.P. Thompson "Time, Work-Discipline and Industrial Capitalism"; Aaron J. Gurevich, "Time as a Problem of Cultural History," in L. Gardet, ed., *Cultures and Time* (Paris : Unesco Press, 1976).

[10] Moishe Postone, *Time, Labor, and Social Domination: a Reinterpretation of Marx's Critical Theory* New York : Cambridge University Press, 1993), 200-225.

[11] Lewis Mumford, *Technics and Civilizations* (New York: Harcourt, Brace and company, 1934); David Landes, *Revolution in Time: Clocks and the Making of the Modern World* (Cambridge: Belknap Press of Harvard University Press, 1983); Anthony J. Turner, *Of Time and Measurement: Studies in the History of Horology and Fine Technology* (Brookfield, VT: Variorum, 1993), 21.

[12] Georg Lukács, *History and Class Consciousness; Studies in Marxist Dialectics*, Rodney Livingstone, trans. (Cambridge, Mass.: MIT Press, 1971); Postone, *Time, Labor, and Social Domination: a Reinterpretation of Marx's Critical Theory*.

[13] See especially Kuriyama Shigehisa 栗山茂久 and Hashimoto Takehiko 橋本毅彦, eds., *Chikoku no Tanjō* 遅刻の誕生 (*The Birth of Tardiness*) (Tokyo: Sangensha, 2001). Or, its English version *The Birth of Tardiness: The Formation of Time Consciousness in Modern Japan*, which appeared as a special issue of *Japan Review* number 14, 2002; an excellent book on Meiji education for punctuality by Nishimoto Ikuko 西本郁子, titled *Jikan ishiki no kindai: "toki wa kane nari" no shakaishi* 時間意識の近代:「時は金なり」の社会史 (*Time-Conscious*

convincingly argue that the rapidly industrialized Meiji period saw a radical shift not only in the official systems of time but also in a wide range of time-related practices, as well as in the very perception of time in general. Yet the words used to describe this radical shift also reflect a very specific idea of what is supposed to be the old, pre-modern temporal order. By stressing the fact that the Meiji period was "the era of time-consciousness,"[14] in which time became modern, abstract and mechanically regular,[15] and in which the very idea of tardiness was first born,[16] such historians, perhaps inadvertently, imply that time consciousness was of lesser importance during the Edo period.

Other authors explicitly claim that the Meiji period marked a conceptual shift in the perception of time. They focus on the creation of new national identity, which was facilitated by the emergence of "scientific" historical discourse.[17] They contrast the new historical mode of thinking to the previous, "mythical" one, which, in their opinion, characterized societies that lived by the cycles of observable changes in the natural world.[18] Undoubtedly, during the Meiji period we see an enormous change in temporal structures, in the material basis that supported the transformation to a Western-style calendar and temporal order, as well as in the rhetoric surrounding that temporal order. These events, however, are meaningful in themselves, and will

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Modernity: a Social History of "Time is Money") (Tokyo: Hosei University Press, 2006); and Stephan Tanaka's *New Times in Modern Japan* (Princeton: Princeton University Press, 2004), especially the "Prelude".

[14] Nishimoto, *Jikan ishiki no kindai*.

[15] Tanaka, *New Times in Modern Japan*, Prelude.

[16] Hashimoto & Kuriyama eds., *The Birth of Tardiness*.

[17] Shimada Shingo, "Social Time and Modernity in Japan," in *Time and Society* (1995, number 4/2), pp. 225-260; Tanaka, *New Times in Modern Japan*.

[18] See Joy Hendry, "Cycles, Seasons and Stages of Life," in *The Story of Time* (London: Merrel Holberton Publishers, 1999); also Asao Naohiro 朝雄直弘, "Jidai kubunron" 時代区分論 (Treatise on the distinction of ages), in *Nihon Tsūshi: Rekishi ishiki no genzai* 日本通史：歴史意識の現在 (An overview of Japanese history: historically conscious present) (Tokyo: Iwanami Shoten, 1995); this notion is also present in Tanaka, *New Times in Modern Japan*.

not lose any of their importance if we do away with the somewhat misleading image of the pre-Meiji temporal order as "natural" or characterized by a lax attitude towards time discipline.

An alternative approach to time takes it to be a historical construct. In his seminal study of time-related notions and practices in late nineteenth and early twentieth century Europe, Peter Galison pointed out the conventional nature of even those temporal structures that came to be considered as "objective" and "scientific."[19] And Jimena Canales, in her excellent book on the history of the "tenth of the second", described the evolution of this temporal construct as a process tying together visual approaches from various fields.[20]

In my study I produce a similar account of a changing arsenal of conventions, patterns of practice and tacit assumptions that shaped the notions of timekeeping, timepieces, and time in Edo Japan. By focusing on the changing approaches to timekeeping, I hope to break away from the tendency to attribute overarching social meanings to conventional patterns and judge those from a present-day normative perspective. At the same time, I stress the continuity of practices between Edo and Meiji period without undermining the scale of dramatic changes of the latter half of the nineteenth century.

[19] Peter Galison, *Einstein's Clocks and Poincaré's Maps: Empires of Time* (London: W.W. Norton, 2003).
[20] Jimena Canales, *A Tenth of a Second* (Chicago: University of Chicago Press, 2009).

Tacit knowledge

My methodology also derives from several approaches in the history, philosophy and sociology of science and technology. The existence of tacit dimensions of knowledge and practice was widely discussed by the philosopher Michael Polanyi,[21] and later developed by historians like Harry Collins who showed how this tacit kind of knowledge is diffused and plays a significant role in the process of conceptualization of experiments.[22] Even more important to this study is the discussion of knowledge tacitly embedded in artifacts by their creators. Lorraine Daston described artifacts as "crystallized experience";[23] Michael Mahoney similarly wrote about "reading" machines from a historical and non-semiotic perspective;[24] and Davis Baird focused on knowledge embedded in *things*.[25] These approaches, which can be characterized as investigations of material epistemology, focused on artifacts mainly in fields of science and technology. Nevertheless, we can also learn about the relationship between humans and artifacts through the investigation of designs. In a series of books on "everyday things" — cars, doors, pencils, etc.,— scholars such as Donald Norman and Henry Petroski investigated the ways humans perceive, use, and modify objects based on their previously existing conceptualization of the world around them.[26]

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[21] Michael Polanyi, *Personal Knowledge; Towards a Post-Critical Philosophy* (Chicago: University of Chicago Press, 1958).
[22] H. M. Collins, "The TEA Set: Tacit Knowledge and Scientific Networks," in Mario Biagoli, ed., *The Science Studies Reader* (New York: Routledge, 1999), pp. 95-109.
[23] Lorraine Daston, "On Scientific Observation", *Isis* 99:1 (2008), p. 103. See also *Things that Talk: Object Lessons from Art and Science* (New York : Zone Books ; Cambridge, Mass. ; London : Distributed by MIT Press, 2004); and *Biographies of Scientific Objects* (Chicago : University of Chicago Press, 2000).
[24] http://www.princeton.edu/~hos/h398/readmach/modelt.html last asscessed May 2012.
[25] Davis Baird, *Thing Knowledge: A Philosophy of Scientific Instruments*, (Berkeley: University of California Press, 2004).
[26] Donald Norman, *The Psychology of Everyday Things* (New York : Doubleday, 1990, c1988), *Turn Signals are the Facial Expressions of Automobiles* (Reading, MA : Addison-Wesley, c1992), *Things That Make us Smart: Defending Human Attributes in the Age of the Machine* (Reading, MA : Addison-Wesley Pub. Co., 1993); Henry Petroski, *Evolution of Useful Things* (New York : Knopf, 1993), *The Pencil: A History of Design and Circumstance*

Another prominent angle of investigation of tacit dimension of knowledge is the historical study of visual practices. Following a series of classic works on visual thinking,[27] scholars such as Jonathan Crary and Lorraine Daston showed how modes of seeing and observing were constructed through specific social settings. [28] Alan Rocke traced the role of visual images and habits of visually identifying architectural structures in defining the structure of molecules.[29] Eugene Ferguson identified imagery as an essential feature of engineering,[30] and Michael Lynch explored the role of unconscious visual perception in scientific practice.[31]

It is, of course, impossible to discuss material, visual, and theoretical realms in isolation. In his discussion of intercalations, Peter Galison provides us with a model that allows the integration of material epistemology, the conscious theoretical level, and intentional observation of nature. According to Galison, scientific practice consists of productive mix of quasi-autonomous traditions, which interact in "trading zones" that connect between theories, instruments, and experiments.[32] My own focus on conventional patterns of practice is meant to emphasize the culturally dependent nature of habitual practices, as well as to stress the often

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(New York : Knopf : Distributed by Random House, 1990), *Small Things Considered : Why There is no Perfect Design* (New York : Alfred A. Knopf : Distributed by Random House, 2003).

[27] E.H. Gombrich, *Art and Illusion; a Study in the Psychology of Pictorial Representation* (NY: Pantheon Books, 1960); Rudolf Arnheim, *Visual Thinking* (Berkeley: University of California Press 1969); Svetlana Alpers, *The Art of Describing : Dutch Art in the Seventeenth Century* (Chicago : University of Chicago Press, 1983).

[28] Jonathan Crary, *Techniques of the Observer: On vision and Modernity in the 19th century* (Cambridge MA & London, England: MIT Press, 1992); Lorraine Daston. "On Scientific Observation," Isis 99:1 (2008), pp. 97-110.

[29] Alan Rocke, *Image and Reality: Kekulé, Kopp, and the Scientific Imagination* (Chicago : The University of Chicago Press, 2010).

[30] Eugene S. Ferguson, *Engineering and the Mind's Eye* (Cambridge, MA: MIT Press, 1992).

[31] Lynch and Law, "Pictures, Texts, and Objects," in *The Science Studies Reader*, ed., Mario Biagioli (New York: Routledge, 1999), pp. 317-341. See also Michael Lynch, "Extending Wittgenstein: The Pivotal Move from Epistemology to the Sociology of Science," in Andrew Pickering, ed. *Science as Practice and Culture* (Chicago: University of Chicago Press, 1992), pp. 215-265.

[32] Peter Galison, *Image and Logic* (Chicago: University of Chicago Press, 1997) and "Trading Zone: Coordinating Action and Belief (1997, abridged 1998)," *The Science Studies Reader*, ed., Mario Biagioli (New York: Routledge, 1999), pp. 137-160.

mundane nature of such practices that go well beyond the professional world and encompass cultural, visual and material realms.

I have also enormously benefited from the literature in the field of sociology of technology. In their seminal study of the development of bicycles, Pinch and Bijker[33] introduced the notion of interpretive flexibility, stressing the fact that any technological design can be interpreted and consequently modified in order to answer a set of specific needs or problems grounded in social practices. Technological development, according to this approach, can be seen therefore as process of solving emerging problems. Another approach, mainly represented by Steve Woolgar,[34] focuses on the process of building meanings for artifacts. In this semiotic approach, artifacts are treated as "signs" that are read and interpreted by their users. Similar to the social construction of technology approach, the semiotic approach stresses that the reading of artifacts is neither random nor completely open. Yet the restraint here is not social but rather material, as the design of artifacts themselves set certain boundaries of interpretation. This approach is echoed by Bruno Latour, who defines artifacts as "hybrids" of social needs and technological obduracy, and focusing on the resistance of artifacts to human whims attributes agency to "non-humans."[35]

These studies, however, tend to begin their investigation at one specific point in time and follow the developments from this point on, as a response to social structure or material constraints. Nevertheless, patterns of behavior, patterns of use, and patterns of interpretation of

[33] Trevor J. Pinch and Wiebe E. Bijker, "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other," in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, eds. Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch (Cambridge, MA: MIT Press, 1987), pp. 17-50.
[34] Steve Woolgar, "Configuring the User: The Case of Usability Trials" in *A Sociology of Monsters*, ed., J Law (London: Routledge, 1991).
[35] A variety of works by Bruno Latour, see especially *Science in Action* (Cambridge, MA: Harvard University Press, 1987); and *Laboratory Life* (Beverly Hills, CA: Sage Publications, 1979).

technology are not only rooted in social structures and existing needs, but also have a history. When coming in contact with artifacts, people don't come to them as a *tabula rasa*, but with assumptions and expectations that shape the very way they approach, interpret and react to the obduracy of artifacts. It is true, as Latour suggests, that cognition happens with actions, but these are not only emerging actions but also previous actions, actions in unrelated fields and actions of predecessors.

My purpose here is no to disprove or argue with the sociological approach, but rather to add a conventional component to this analysis. By investigating the technological development of Japanese clocks, I hope to show that in the process of interpretation of technology, people use patterns rooted in their previous history; that is, the obduracy of technology is often created by existing assumption of what is possible and impossible, and people carry over interpretational patterns from previous practices or from other fields of practices without inherent social necessity.

History of Japanese Science and Technology

The history of time-related technology in Edo period is intimately connected to the history of sciences of that period, especially the sciences associated with the practice of "observation and measurement"[36] — astronomy, geography and navigation. In discussing the changes in timepieces and time-keeping practices in those fields, I hope to both illuminate the crucial importance of this, often overlooked, episode in the history of Japanese sciences, and to

[36] Today, the word *sokuryō* 測量 is usually used reserved for "measurement" only, even narrowing down to "surveying". In the latter half of the Edo period however, the word was often used to signify "measurement by means of observation", implying that "observation" (*kansoku* 観測) is an inherent part of measurement.

stress the role of conventional patterns of practice and tacit assumptions in the process of conceptualization and integration of foreign knowledge.

The "science" of Edo period Japan is often conflated with so called "Dutch Studies" — *Rangaku*.[37] This association, nevertheless, can be very misleading in several different ways. First of all, the very term "Dutch Studies" that designates Holland as a source of all knowledge about the West can lead to quite erroneous conclusions. In the late Edo period, the word *ran* had a general meaning of foreign things and could be applied to artifacts coming from Holland, England, Germany, France or Russia. Interpreters who may have started as Dutch experts were also learning English, French and Russian. Moreover, prior to the nineteenth century, in professional astronomical circles *all* knowledge about Western astronomy came from treatises written by Chinese students of Jesuit astronomers in China and imported to Japan.

Additionally, even though the majority of professionals were interested in Western sciences to a certain degree, there were only a few people who actively identified themselves as "Dutch Scholars,"[38] certainly before the beginning of the nineteenth century. Those who did do so in the eighteenth century were mostly those dealing with the task of translation, either as officially employed interpreters or as scholars interested in issues of language or popular authors fascinated by novelties. A simple equation of Edo sciences with *Rangaku* leads to rather flawed conclusions that learning Western sciences was done exclusively through translation and that it

[37] 蘭学, *ran* in *Rangaku* is a short form of Japanese term for "Dutch" — *oranda*. See for example John Bowers, *When the Twain Meet: The Rise of Western Medicine in Japan* (Baltimore: Johns Hopkins University Press, 1980); Sugimoto and Swain, *Science and Culture in Traditional Japan* (Rutland, VT: Charles E. Tuttle Co., c1989); Grant K. Goodman, *Japan and the Dutch*, Curzon Press, Richmond, 2000; Numata Jirō, *Western Learning* (Tokyo: Japan-Netherlands Institute, 1992) and Sugimoto Tsutomu 杉本つとむ, *Edo jidai Rangogaku no seiritsu to sono tenkai* 江戸時代蘭語学の成立とその展開 (Establishement and Development of Dutch Language Studies in Edo Period) (Tokyo: Waseda Daigaku Shuppanbu, 1976-1982); and *Edo no honyakutachi* 江戸の翻訳家たち (Edo Translators) (Tokyo: Waseda Daigaku Shuppanbu, 1995).

[38] *Rangakusha* 蘭学者.

was a kind of playful entertainment. Mechanical technology too is consequently discussed in terms of exotics and showpieces[39] that served exclusively to satisfy an appetite for curiosities and wonders.[40] It is not to say that professional astronomers did not have any relations to interpreters and popular authors, but they themselves had different goals and practices, and often disagreed with both the interpreters and the popular visions of Western science.

We should also be wary of the opposite tendency to depict astronomical practices in overly rationalized and teleological terms. These trends are clearly seen in the canonical study of Shigeru Nakayama,[41] but can also be identified in writings of early and mid twentieth century historians of Japanese science.[42] These foundational studies supplied me with crucial information about astronomical practices and oftentimes provided transliterations of difficult source materials. Nevertheless, their focus on the "usefulness" of Western science and its inevitable triumph lead them to undervalue and sometimes dismiss what they deemed "mistakes," overlooking the diverse motivations and experimental thinking of Japanese astronomers. Later twentieth century historians of Japanese science focused their research on specific episodes in history of Japanese science and provided me crucial insights into the practical, technological and social aspects of scientific practices of the period. [43] I am deeply indebted to their research, which enabled me to develop my own investigation.

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[39] *Misemono* 見せ物.

[40] Timon Screech *The Lens Within the Heart*: *The Western Scientific Gaze and Popular Imagery in Later Edo Japan* (Honolulu: University of Hawaii, 2002) and "Clock Metaphors in Edo Period," in *Japan Quarterly* (Oct-Dec. 1996), pp. 66-75.

[41] Shigeru Nakayama, *Japanese Astronomy* (Cambridge, Mass.: Harvard University Press, 1969), and 中山茂, *Nihon no Tenmongaku* 日本の天文学 (Japanese Astronomy) (Tokyo: Iwanami Shoten, 1972). The Japanese version of the book is the only thorough book on the history of Japanese astronomy in English.

[42] Watanabe Toshio 渡辺敏夫, *Kinsei Nihon tenmongakushi* 近世日本天文学史 (*History of Early Modern Japanese Astronomy*), (Tokyo: Koseisha Koseikaku, 1986-7), Ōtani, Ryōkichi, *Tadataka Inō*, Sugimura Kazue, trans. (Tokyo: Iwanami Shoten, 1932).

[43] Takehiko Hashimoto *Historical Essays on Japanese Technology* (Tokyo: Collection UTCP, 2009), Nakamura, Tsukō 中村士, *Edo no Tenmongakusha Hoshizora wo Kakeru* 江戸の天文学者 星空を翔ける(*Edo Astronomers*

In the recent years we do see attempts to both make a thorough investigation of the Japanese case and to use it to arrive at broader conclusions about science, technology and society.[44] This recent scholarship makes a significant contribution to our understanding of processes through which technologies were conceptualized, problematized and modified.

By emphasizing the role of established patterns of practice in analyzing new information, I hope to shift the attention from the content of foreign knowledge as retrospectively seen from a modern-day point of view, to the very modes this information was received with. It is simply not enough for us to know what book or theory arrived to Japan; we must also investigate the methods these were approached by in order to fathom what exactly was understood and how it was used. From this point of view, the process of knowledge transmission can no longer be seen as a passive act of reception, or as more or less successful attempts to arrive to some kind of truth. Rather, it reveals a creative and active process in which information was not only dissected and analyzed, but also actively transformed.

Unexplored Times

Unfortunately, the limited scope of this dissertation will not enable me to sufficiently develop several important themes. One of those themes is scientific translation of time-related notions that certainly deserves a full-length investigation of its own. The intricate process of

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Fly in the Starry Skies) (Tokyo: Gijutsu Hyoronsha, 2008); Watanabe Makoto 渡辺誠, "Kanazawajō jōshō no yakuwari to jikokuseido no hensen 金沢城城鐘の役割と時刻制度の変遷について (On the Tranformaitons of Time Systems and the Role of the Castle Bell of Kanazawa Castle"), in *Edo no Monodukuri* 江戸のモノづくり (*Artisanship of Edo period*), (Tokyo: Seika Hōkoku, 2006), Tadashi Yoshida, "The Rangaku of Shizuki Tadao" Ph.D.. Dissertation, Princeton, 1974.

[44] Federico Marcon, "The Names of Nature: The Development of Natural History in Japan, 1600-1900," Ph.D.. Dissertation (Columbia University 2007); Alexander Bay, "The Politics of Disease: Beriberi, Barley, and Medicine in Modern Japan (1700--1939)," Ph.D.. Dissertation (Stanford University, 2006); Brett Walker, *The Conquest of Ainu lands: Ecology and Culture in Japanese Expansion, 1590-1800* (Berkeley: University of California Press, 2001), Greg Clancey, *Earthquake Nation* (Berkeley: University of California Press, 2006).

constructing meanings following an encounter with foreign-language texts has only been recently problematized in the field of natural history.[45] However, the role of this process in time-measuring practices of early nineteenth century astronomy, geography and navigation awaits deeper and more focused research, which will certainly be a part of my future project.

Another venue that awaits further investigation is a comparative study of early modern Japanese and Chinese clocks. It seems that although mechanical timekeeping technology arrived in China and Japan at the same time and in similar circumstances, the paths timekeeping technology took in these two places were strikingly different.[46] A comparative study of the two cases has a great potential of revealing more factors that shape technologies and I look forward to undertaking such a study in the future.

There are areas that I only briefly touch upon in the current study, such as time-related concepts and practices in literature and religion. In these fields I rely on the expertise of others.[47]

Chapters

This dissertation begins with an investigation of the temporal landscape of Edo period Japan. Looking into the patterns of timekeeping and time management both within a day but also throughout the year, I claim that the temporal systems of the Edo period were longstanding conventions, which were neither necessitated by "nature" nor determined by some kind of broad characteristics of Edo society. These conventions remained in use throughout centuries of historical changes, and the evolving social practices were built and transformed within their boundaries. Consequently, conventional systems provided Edo people with concrete tools to

[45] Federico Marcon, "The Names of Nature".
[46] Catherine Pagani, *Eastern Magnificence & European Ingenuity* (Ann Arbor MI: University of Michigan Press, 2001).
[47] See Haruo Shirane, *Japan and the Culture of the Four Seasons* (New York: Columbia University Press, 2012); Lucia Dolce, *The Worship of Stars in Japanese Religious Practice* (Bristol, UK: Culture and Cosmos, 2007).

approach time-related issues, yet allowed enough flexibility for adjustment to the wide range of different "times" employed in a variety of evolving situations.

The focus of chapter two shifts from overarching and explicit conventions to a more implicit and tacit level of assumptions involved in the handling of time-keeping technology. Tracing the evolution of Japanese clocks, I examine the process of incorporation of European mechanical clock-making technology into the temporal landscape of the Edo period, and show how Japanese clockmakers reinterpreted this novel technology, developing designs of clocks that barely resembled their European ancestors. I claim that some of the modification did not derive from the need to adapt to existing social conditions and practical problems, but were grounded in the existing timekeeping practices, assumptions about the nature of time, and conventional patterns of visualizing time. Consequently, the initial stages of "reading" foreign technology were already shaped by pre-existing and culturally-laden patterns of seeing and handling an artifact, which were based on previous timekeeping experiences.

Chapter three stresses the importance of existing practices and assumptions not only in the immediate sphere of timekeeping but also in areas deemed relevant by clocks' users. Narrowing down on the field of Edo period Japanese astronomy, I point out the correlation between specific designs of timepieces and the particular motivations and methods of various astronomers. By doing so, I show that even though each one of the timepieces measured time, "time" was just an algorithm that enabled measurement and scrutiny of a variety of factors. In spite of the fact that, broadly defined, the goals of various astronomers appear to be similar, their approaches to time-measurement were shaped by the different mathematical methods they employed, and particular astronomical problems that preoccupied them.

Chapter four takes the relation between timekeeping and associated practices even further and claims that patterns of practice were carried over from one field to another, creating a link between the conceptualization of time and space. The chapter begins by following the events that brought about the incorporation of the pendulum clock into geographical practice, and shows how astronomical timekeeping made for the purpose of determination of latitudes and longitudes in turn motivated a reconceptualization of geographical space as one organic and objective continuum. The second part of the chapter traces the ways these geographical timekeeping practices were carried over to the field of open sea navigation, which remained hypothetical until the final years of Edo period. As astronomical and geographical timekeeping methods went through yet another transformation following the incorporation of Western chronometers into astronomical practice, these evolving methods were applied to imagined conditions of hypothetical sea voyages. I claim that in this process new patterns of timekeeping practice emerged and the range of tacit assumptions about the time and timekeeping shifted. Consequently, new patterns of practice provided late Edo period scholars with a new repertoire of tools that enabled them to reconceptualize "time" as universal and objective entity.

Chapter five moves away from professional practices and goes back to broader cultural aspects. Focusing on the realm of associations and metaphors, chapter five traces the change in the cultural values attached to mechanical clocks. There is no doubt that mechanical clocks were popular throughout the Edo period, but the real question is the reason behind this popularity. Examining the "usual" suspects — technological advantage, rarity and exotic origin — we discover that clocks were popular *despite* the fact that they were expensive, cumbersome, prone to frequent failures and did not offer any practical advantage over the non-mechanical timepieces; we also find that they were not as rare as previously thought, and were hardly

considered to be exotic or mysterious. Rather, clocks were considered to be fascinating because they were mechanical. The cultural implications of "mechanical," however, developed throughout the period, moving from a close association with the art of automata, to an educated interest in the mechanical structure, to an assumption that clocks embedded basic natural principles and could serve as a metaphor of the universe.

Chapter six tackles the question of change in conventional temporal patterns by discussing the developments leading to the 1873 reform, which abolished the existing variable-hours system and adopted a Western style timekeeping notions and technology. In this chapter I argue that reform in the timekeeping system was less grounded in practical needs, than it was a by-product of calendrical reform. Furthermore, I claim that rather than creating a revolution in timekeeping convention, the reform only affirmed already transformed practices on the ground. This transformation was motivated by the growing association of timekeeping with what was considered to be "progressive" areas — mechanic motion, economic efficiency, idealization of the West, and with professional fields of astronomy and navigation. The understanding of the Western convention, however, was not easy, as many aspects of Western timekeeping systems were seen as counter-intuitive or even nonsensical, and it was not even clear which elements out of all the plethora of information contained on the clock dial were relevant for timekeeping. The complicated conceptual process of bridging this gap involved finding and employing familiar patterns of practice for the conceptualization of the foreign system, gradually developing new habits of seeing and deciphering information. The subsequent adoption of Western temporal conventions was therefore a consequence of a lengthy process of changing the very approach to time and time-related practices, and the range of assumptions tacitly or explicitly associated with them.

Chapter 1: The Temporal Order in Tokugawa Japan

Introduction

"Clocks!? *Mechanical* clocks in Edo period? What did they use them for? Japanese didn't really care about time before the Meiji period!" Responses like this are certainly not uncommon among people who first hear about Edo period Japanese clocks. Foreigners and Japanese alike, many find the term "Edo-period clock" to be an obvious oxymoron: after all clocks are the symbols of modernity, efficiency and precision, while the Edo period is often associated with agrarian, and "traditional" life style. Even those who have heard about these devices, or happened to visit the charming little "Daimyō Clock Museum" in Tokyo, assume that clocks were not functional but rather served as expensive toys, which only rich people on the level of *daimyō*, lords of provincial domains, could afford.

This popular sentiment is not entirely divorced from the academic literature, at least the more widely known versions of it. The classic article by E.P. Thompson[48] is often cited in support of the modern/pre-modern, urban/agrarian, feudal/capitalist or concrete/abstract divide. Consequently, the so-called pre-modern and pre-industrial societies are too often described as "natural," living according to the lunar and solar cycles, and attuned to the seasonal changes in the weather. The excellent literature describing the major changes in time-consciousness in modern Japan[49] had an unfortunate side effect of creating an illusion that prior to the mid-19th

[48] E.P Thompson, "Time, Work-Discipline and Industrial Capitalism", in *Past and Present*, vol 38 (December 1967), p. 60. For detailed discussion of time-related literature see *Introduction*.

[49] See especially Kuriyama Shigehisa 栗山茂久 and Hashimoto Takehiko 橋本毅彦, eds., *Chikoku no Tanjō* 遅刻の誕生 (*The Birth of Tardiness*) (Tokyo: Sangensha, 2001). Or, its English version *The Birth of Tardiness: The Formation of Time Consciousness in Modern Japan*, which appeared as a special issue of *Japan Review* number 14, 2002; an excellent book on Meiji punctuality by Nishimoto Ikuko 西本郁子, is titled *Jikan ishiki no kindai: "toki wa kane nari" no shakaishi* 時間意識の近代:「時は金なり」の社会史 (*Time-Conscious Modernity: a Social*

century there was no time-consciousness in Japan at all. Sure enough, the temporal practices of the Edo period, as well as the systems they were based on, and the means they employed, were very different from those known to us today. Yet these differences should not undermine the vibrant nature of Edo temporal practices, the characteristics of which changed throughout two hundred and seventy years of this period.

In order to better understand the evolution and the role of mechanical clocks in the private, social and professional lives of many individuals in Edo period, let us first examine the temporal systems of that period and the practices associated with them. Although on a surface level some of the Edo period temporal structures may appear "natural" or "agrarian," a closer look at them reveals that there was nothing natural about these man-made systems, and there was nothing about them that should have prevented the use of timepieces, mechanical or others. The supposed intimacy with nature was no more than a constant reproduction of conventional patterns of temporal behavior. These long-standing conventions reflected neither some kind of permanent collective psyche, nor fixed social structures; rather, they provided a framework within which people developed specific patterns of approaching, managing and measuring time.

Counting the Hours

Similar to the temporal systems used in medieval periods in Europe and in China, early modern Japan used the so-called variable hours system,[50] in which the length of hours varied

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History of "Time is Money") (Tokyo: Hosei University Press, 2006); and Stephan Tanaka's *New Times in Modern Japan* (Princeton: Princeton University Press, 2004), especially the "Prelude".

[50] Japanese term is *futeijihō* (不定時法) and it was used as early as eighteenth century in treatises comparing Japanese systems with others. The literal translation of the term is "undetermined hours", that stresses not the changing nature of the hours but rather the fact that hours were seen as not bound by universally predetermined limits. Nevertheless, the word "undetermined" in English might imply a sense of hesitation and lack of resolution, and therefore I will use the standard translation of this term as "variable hours". For more detailed discussion of Japanese perception of their own system compared to the system of equal hours see chapter six.

with the seasons. Each day was divided into a daytime and nighttime periods, and each of the two was further divided into six equal periods called either *toki (ji)* or *koku*,[51] often labeled in the English-language literature by the somewhat confusing term "double hours," referring to the fact that there were twelve such units in a day. Nevertheless, since the relative length of daytime and nighttime changed with the seasons, the length of daytime "double-hours" and nighttime "double-hours" changed accordingly. Consequently, they could be as short as 76.75 modern-day minutes or as long as 155.952 minutes,[52] and it was only around the time of the equinoxes that both daytime and nighttime "double-hours" measured roughly two hours in modern terms.[53]

Each of the twelve hours was named according to one of the twelve animal signs,[54] and given a number that could be announced by a bell. The animal sign assigned to each hour was supposed to parallel one of the twelve months in the following manner: midnight corresponded to the darkest month of the year (around the winter solstice), and hence received the same sign, rat; and noon, when the sun is in zenith, corresponded to the brightest month of the year (around the summer solstice), thus receiving the same sign, horse.[55]

Interestingly, unlike the numbers on the Western clock, Japanese hours were not counted in a consecutive series of 1 to 12. Instead, the midnight hour was hour number 9, and the following hours were numbers 8, 7, 6, 5, and finally 4, which was the final hour before noon; the

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[51] During Edo period all the terms related to the division of the day, including 時 (*toki/ji*), 刻 (*koku*), 剋 (*toki/koku*) and 辰 (*toki/koku/shin*) were used interchangeably, and it was only in the 19th century that some scholars attempted to create strict rules that distinguish between, variable and invariable units and their various subdivisions.

[52] These numbers are based on the calculations of Honda Toshiaki 本多利明 in *Shisei chiji kagami* 視星知時鑑 (*Looking at the Stars —Knowing the Hours*), 寛政一 (1789), Kano Archive.

[53] Therefore I will refer to these units by the term "hours", which also would be the best translation for any of Edo period terms.

[54] *Shi* 支. Rat, ox, tiger, rabbit, dragon, snake, horse, sheep, monkey, rooster, dog, wild boar. Also commonly known as "the signs of the zodiac", or as twelve "terrestrial branches" that together with ten "celestial stems", *kan* 干, served as the basis of ancient Chinese cosmology.

[55] In the Edo period the noon was considered to be a moment when the sun crossed the meridian. Today, we should remember that due to the time equation and regional time differences, our local noon rarely coincides with 12 o'clock.

noon hour was again numbered 9, with consecutive hours numbered again 8, 7, 6, 5, and finally 4, the hour before midnight.[56] This count might seem peculiar to a modern-day reader used to our present conventions. But we should not assume that there was something inherently "Edo" or "Japanese" about it. As we can see, Edo-period thinkers too were bothered by the question "why do we count the hours the way we do?"

According to Edo period sources, the origins of this double sequence came from the ancient Chinese *Classic of Changes*,[57] and it was supposed to represent the correspondence between the twelve hours, the twelve months, and the yearly cycle of birth and decay. In the *Classic of Changes*, each stage in this cycle is represented through a hexagram. The darkest month of the year is when the dark yin energy is most dominant and the bright yang energy is just starting its return. This is represented by the hexagram called "return" , in which five broken lines symbolize the plentiful *yin* and the single unbroken one refers to the weak *yang*. In the second month, represented by the hexagram "approach" , the yang starts growing, and continues to grow with each month until it reaches its peak just before the summer solstice, represented by the hexagram "(full) force" . Since the cycle of hours mirrored the cycle of months, they too were associated with the same series of hexagrams. Next, each hexagram, and hence each hour, could be discussed in numerical terms. Each unbroken yang line at the bottom of a hexagram was assigned the number nine. Multiplying the number of unbroken yang lines by nine gave the following series: the first hexagram was represented as the number 9 (1x9), the

[56] A separate system was sometimes used for the night hours, which would be referred to by the term *kō* (更) and counted in a consecutive way. When this system was implemented the night was divided to five equal *kō* and each *kō* was divided to five equal *ten* (点). Bell keepers would have a special conversion table that showed them at what hour (時) one should mark the beginning of *kō*. Minamoto Sanuyoshi 源誠美, *Tenji Meikai* 天時明解(Explication of Heavenly Time), 享和二 (1802), Kano Archive, p. 25.

[57] *Yi Jing* 易經.

second as 18 (2x9), and so on 27, 36, 45, 54. From this series, another series of numbers was derived by taking only the second digit of each number in the first series: 9, 8, 7, 6, 5, 4. Those were the numbers assigned to the hours from midnight to just before noon. Noontime, in turn, corresponded to the summer solstice, in which the yin is born and begins its own process of growth. Since the two processes of growth, that of the yang and that of the yin, mirror each other, the hours from noon to midnight were also assigned the same series of numbers from 9 to 4.[58]

It is nearly impossible to know whether Edo scholars were indeed right about the origins of the number sequence, nor did they themselves claim this to be an undeniable truth. Their research of ancient Chinese texts was not much different from a work of the modern historian and they too looked for the history rather than some kind of underlying metaphysical truth. Their consensus was that, whatever the exact origin, the numbers were used in Japan following the decision of emperor Tenchi[59] in the seventh century, as part of the adoption of the Chinese time system.[60] In other words, Edo scholars deemed their temporal system to be a human construct and accepted it as purely conventional.[61]

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[58] Anonymous, *Jūniji shōko no kazu* 十二時鐘鼓之数 (*The Numbers of the Twelve Hours of Bells and Drums*) copy from 享保五 (1720). National Museum Archive; Terajima Rōan 寺島良安, *Wakan Sansai Zue* 和漢三才図絵 (*Illustrated Sino-Japanese Encyclopedia*), 正徳三 (1713), scroll 7, *Reki Uranai* 暦占("Calendarical divination"), (http://record.museum.kyushu-u.ac.jp/wakan/wakan-ten/page.html?style=b&part=7&no=8 last accessed April 2012), briefly mentions the origin of the multiplication; Drummond Robertson *The evolution of clockwork* (London: Cassell, 1931) and N. H. Mody *Japanese clocks* (Rutland: Vt., C. E. Tuttle Co., 1967) explain the sequence by a similar multiplication of the number nine, but they do not point to the *Classic of Changes* as a source and fail to explain why the multiplication ends at six and then starts over again. Wilhelm Brandes, "The Secret of Japanese Clock Dial" in NAWCC Bulletin No. 172: October 1974, pp. 531-565, dismissed what he called "numerical mysticism" and sought to find a more "rational" explanation. At the same time he admitted that "considering my complete ignorance of these languages [e.g. Japanese, Chinese and Korean] and only very superficial knowledge of astronomy, there mere attempt at understanding and working with all these data seemed a pointless waste of time". pp, 534-535.

[59] 天智天皇.

[60] Both *Wakan sansai zue* (*Illustrated Sino-Japanese Encyclopedia*) and *Jūnijishōko tokei* (*The Numbers of the Twelve Hours of Bells and Drums*) say this.

[61] We can see this in other instances as well. In his discussion of the unit of the "day" astronomer and mathematician Nakane Genkei 中根元圭 (1662-1733) makes a clear distinction between the time of astronomical phenomena and human time (天ノ昼夜 is contrasted to 人ノ昼夜). Nakane Genkei, *Jikokuron* 時刻論(*Treatise on Time and Hours*)

One aspect that did not develop into an overarching consensus was the division of the hour into smaller units called *bu*,[62] which can simply be translated as "division". Each *bu* was supposed to measure one-tenth of an hour, though it seems that in earlier times it measured only one-fourth. Traces of this older division are found in the folk expression *ushi-mitsu*, which referred to the time of night when the ghosts and demons were supposed to come out, the literal meaning of which is "the third (quarter) of the (hour of the) ox." In fact, it seems that this was the only usage of the quarter-hour count in the Edo period, and Edo scholars always referred to this conventional expression when pointing out the existence of this kind of hour-division. Instead, people referred to the "upper" and "lower" parts of the double hour,[63] or to the "beginning" and "true" hour,[64] to indicate the subdivision of the hour. The actual use of these terms, however, differed in various locations. In some places the term "true hour" was used to refer to the exact middle of the double hour, but in other places it indicated the second half of the hour. There was also no consensus as to whether "upper" and "lower" parts of these meant two halves of each hour, or whether the lower part of a certain hour was identical to the upper part of the next one. It was only in the early nineteenth century that scholars deemed these different conventions to be inconsistent and struggled to enforce a unified hour-division system to be "correctly" used by the general public.[65]

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unpublished manuscript, date unknown, Tohoku University Japanese Mathematics Materials (*Wasan Shiryō* 和算資料) Database (http://dbr.library.tohoku.ac.jp/infolib/user_contents/wasan/l/f033/10/f033100007l.png, last accessed April 2012).

[62] 分. According to Professor Yoshida Tadashi 吉田忠 of Tohoku University, in the timekeeping context this character should be read as *bu*.

[63] *Jōkoku* 上剋 and *gekoku* 下剋 (also written with the character 刻).

[64] *Shokoku* 初剋 or *seikoku* 正剋 (also written with the character 刻).

[65] Honda Toshiaki 本多利明, *Toki no kane duke* 時の鐘附 (*Appendix to Time-Bells*), 文化十三 (1816), Tohoku University Kano Archive.

Managing Heavenly Disharmony

But how did one determine the precise length of the hours? The system of undetermined hours might evoke nostalgic notions of "natural" time, attuned to the natural motion of the sun and the moon and the seasonal changes in the length of the day. So, one might assume that daily changes in the length of the hours were simply deducted from natural phenomena. Nevertheless, looking closer at the calculations required to maintain such a system, we see that it was anything but "natural." First of all, the system of undetermined hours required a definition of the exact moment that separated night and day.[66] There is no "natural" way to define this moment, however, because what we define as "dawn" or "sunset" is not a specific point in time but a gradual process that sometimes takes more than an hour. Intuitively, it is very tempting to claim that this point is when the sun appears above the horizon (or disappears below it). But, to mention just one of the many problems, unless one is at sea, it is difficult to define what this "horizon" exactly is. More importantly, the sky usually brightens up before the sun itself can be seen, so that in terms of brightness, the day starts much earlier than sunrise. One rule of thumb was to look at one's hand: if there was enough light so that one could distinguish the three main lines on the palm of the hand then it was still, or already, daytime, but this was no more than a very subjective rule of thumb, that could hardly be used in a society that aspired to a certain degree of coordination.

Moreover, the difference between the length of daytime and nighttime seems obvious when comparing winter days to the summer ones, but it is hardly noticeable when comparing a specific day to the following one. Unlike the temporal convention of the Muslim world, the daily change was deemed to be insignificant in Japan, and it was decided to change the length of the

[66] In Japanese, the sixth hour of dawn (明け六つ *akemutsu*) and the sixth hour of dusk (暮れ六つ *kuremutsu*).

hour only when the difference became significant. But what is a "significant" difference? There was no "natural" unit of time that could indicate such a significant period. In order to address this issue, ancient Chinese astronomers, who shaped the calendrical system that was later imported to Japan, came up with the solution of sub-seasons and sub-sub-seasons that divided a year. A solar year was defined as the period between two consecutive winter solstices, and it was divided into twenty-four equal meteorological phases called *sekki*,[67] each measuring approximately fifteen days.[68] Each *sekki* received a name signifying seasonal changes either in atmospheric phenomena or related agricultural activities, such as "*great heat*," "*white frost*," "*rain on the grain*," or "*beginning of spring*." Other *sekki* names indicated the beginning of the one of the "major" four seasons,[69] or important astronomical events such as equinoxes and solstices. Each *sekki* was further divided into three environment-oriented episodes called *kō*,[70] which were supposed to represent more specific changes in the flora and fauna, such as the appearance of insects after their winter hibernation, the return of migrating birds, the blooming of various flowers and trees, etc.[71]

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[67] 節気.

[68] Today, the solar year, also referred to as the tropical year, is defined as a period between two consecutive vernal equinoxes and is measured as 365 days, 5 hours, 48 minutes, 45.51 seconds. Obviously this number does not divide by any whole number of days, and so slight variations in the length of some *sekki* had to be introduced. The accurate value of *sekki* that was used by Edo period calendar makers was 15.21 days. Minamoto Sanuyoshi, *Tenji meikai*, pp. 3-4.

[69] Another problem was that the seasons did not fit the correspondence theory of yin-yang and the five phases. The four seasons seem to fit perfectly four out of five phases: the blossoming spring corresponded to wood, the hot summer to fire, the golden leaves of autumn to metal, and the rainy winter to water—yet there was no season to correspond to the earth phase. To solve this, a fifth, somewhat irregular "earth" season, called doyō (土用), was added, and it occurred during the last eighteenth days of each of the other four seasons. Obviously, this pseudo-season did not correspond to any climatic phenomena, and was rather a calendrical device designed to bridge inconsistencies inadvertently created by the cosmological system.

[70] 候

[71] Kusa Dōin 久佐 道允, *Shichijūnikō-shō* 七十二候抄 (*Excerpt of the Seventy Two Seasons*) vol 1-2. 貞享三 (1686), Waseda Japanese and Chinese Classics Database Online (http://archive.wul.waseda.ac.jp/kosho/ni05/ni05_02516/, last accessed April 2012); *Wakan Sansai Zue* (*Illustrated Sino-Japanese Encyclopedia*), fourth scroll, *Jikō rui* 時候類 (*Types of Times*). (http://record.museum.kyushu-u.ac.jp/wakan/wakan-ten/page.html?style=b&part=7&no=5, last accessed April 2012).

Looking at the names of the *sekki* and *kō* it is very tempting to conclude that Edo period Japanese were highly attuned to minute seasonal changes and the natural phenomena around them. But this was not necessarily so, because the names used in Edo Japan were inherited from the ancient Chinese calendar and therefore, if anything, were supposed to reflect changes in the natural environment of northern China, where this system was created.[72] Consequently, we should not be surprised to find that the list of *kō* featured animals like tigers, which do not inhabit the Japanese islands, and that the timing of natural phenomena according to *kō* was different from the time they occurred in Japan. Not to mention that Japan itself was far from being climatically homogenous, which made those names even less indicative of natural cycles in various areas.

People, of course, were not oblivious to these discrepancies. After all, it is not hard to notice that the period called "*beginning of Autumn*" was in fact the hottest period of the year,[73] while the period "*snow turns into rain*" might in fact bring sudden snowstorms to areas that do not see much snow during the winter at all.[74] Already in the seventeenth century this discrepancy was problematized by the astronomer Shibukawa Shunkai,[75] prompting the creation of a different list of *kō* names that would better correspond to natural events in what he perceived as the Japanese climate, and inspiring later generations of *Nativist* scholars[76] to dwell on the issue of

[72] Mitsuru Sōma, Kinaki Kawabata and Kiyotaka Tanikawa, "Units of Time in Ancient China and Japan," in *Publications of Astronomical Society of Japan*, vol. 56 (2004), pp. 887-904.
[73] The title "beginning of Autumn" can of course be explained in ying/yang terms when the peak of one element brings about the beginning of its opposite. The problem is that one cannot point out in the same way "the peak" of spring or autumn, and although "beginning of spring" season starts while it is still cold, in central Japan the winter is certainly past its peak at that time. So even if the name of the "beginning of autumn" season does derive from the ying/yang theory of opposites, its counterparts certainly fail to adhere to the same principle.
[74] This specific discrepancy is pointed out by Okada Yoshirō 岡田芳郎 in *Kyūreki no yomihon* 旧暦の読本(*Old Calendars Reader*) (Osaka: Sogensha, 2006), p. 143.
[75] 渋川春海 1639-1715. Also called Shibukawa Shunkai (same characters).
[76] Scholars of so called *Native Studies – Kokugaku* 国学, who emphasized local history and tradition.

the Japanese calendar.[77] But scholarly debates aside, the general population was reluctant to part with convention, and kept using the less accurate yet familiar Chinese *kō* names.

Incompatibility of man-made seasons to the actual meteorological phenomena was perhaps one ill that people could ignore, but there was another incompatibility that simply couldn't be ignored — the incompatibility of solar seasons with lunar cycles. As one can easily see from the etymology existing in virtually every language, the man-made period of "month" is based on the phases of the moon. The first day of a month[78] was defined as the day when the moon was positioned directly between the earth and the sun and was not visible at all; after approximately seven days the period of a waxing crescent[79] began, and ended on either the fourteenth or the fifteenth of the month with the full moon;[80] in another seven days or so the period of the moon's waning[81] began and ended with its total disappearance from the view on the last day[82] of the month.[83] An alternative way of dividing the month was into three parts, each of approximately ten days: the first part signifying the waxing phase; the second signifying the period of more or less full moon; and the last referring to the waning moon.[84] Whichever division was chosen, by looking at the phases of the moon it was possible to know, approximately, what day of the month it was.

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[77] Yamamoto Shinsaburō 山本 沈三郎, *Shichijūnikō idōkō* 七十二候異同攷(*Examination of Similarities and Differences in the Seventy Two Seasons*), 安政四 (1857), Waseda University online collection of Japanese and Chinese Classics (http://archive.wul.waseda.ac.jp/kosho/ni05/ni05_02682/ni05_02682.html last accessed April 2012); reprinted in Okada Yoshirō, *Kyūreki no yomihon*, pp. 142-165. For discussion of nativists' reflection on the calendar see Sato Masatsugu 佐藤政次, *Rekigakushi taizen* 暦学史大全 (*Encyclopedia of History of Calendrical Science*) (Tokyo: Surugadai shuppansha 1977), pp. 3-10.

[78] *Tsuitachi, sakujitsu* 朔 or, 朔日, the etymology of the character means "moon is coming back to its origin."

[79] *Jōgen* 上弦.

[80] *Mangetsu* 満月 or *mochi* 望.

[81] *Gegen* 下弦.

[82] *Misoka* 晦 or, 晦日.

[83] Terajima Ryoan, *Wakan sansai zue* (http://record.museum.kyushu-u.ac.jp/wakan/wakan-ten/page.html?style=b&part=6&no=12 last accessed April 2012).

[84] *Jōjun* (上旬), *chūjun* (中旬) and *gejun* (下旬).

Here one has to stress that this human manner of dividing the moon's cycle was only a rough estimation, since the length of moon's cycle is actually 29.53 days,[85] and therefore it can be neither divided into four phases of seven whole days, nor into any whole number of days at all. To adjust this odd length to human standards, the solution was to define shorter months of twenty-nine days and longer months of thirty days. This meant that in the first method of subdividing the month, the divisions could be either seven or eight days long, while according to the second method, there would sometimes be a shorter division lasting nine instead of ten days.

Another problem with natural cycles was that twelve lunar months only add up to 354 days, which does not align perfectly with the solar year of roughly 365 days. The solution here was to add an intercalary month[86] in certain years. The rule of thumb, which was invented already in ancient China, was that there should be seven intercalary months for every nineteen years.[87] To put it more simply, the intercalary month was inserted when the difference between the length of the lunar month and one-twelfth of a year added up to one month.

Of course, the four seasons were independent of lunar cycles, and yet it was customary to say that the first three months of the year, which began around early February in our terms, were the spring, followed by three months of summer, three months of autumn, and three months of winter. While there were some who argued that each season should start in the middle of a month and not on its first day, they too maintained that all four seasons were three months in length.[88] The intercalary month, of course, did not properly fit into this scheme, but here convention allowed it to be considered an exception.

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[85] The fact that moon's cycle is roughly 29 and a half days was widely known since the antiquity. In the Edo period it was accepted that lunar month is 29.53 days, rather close to the modern value of 29.53059 days. These values were recorded by Minamoto Sanuyoshi, *Tenji meikai*.

[86] Jap: *urūzuki* 閏.

[87] Nathan Sivin, "Cosmos and Computation in Early Chinese Mathematical Astronomy," in *T'oung pao*, vol. 55 (1969), pp. 1-73.

[88] *Wakan Sansai Zue*, fourth scroll, *Jikō rui*.

All these complications, caused by the inherent incompatibility of the various natural cycles, such as days, lunar months and years, made it virtually impossible to live "according to the nature." For any society, in order to function as society and maintain at least a minimum level of coordination it was necessary to make decisions and force the natural cycles into a conventional, man-made structure of the calendar. Luni-solar calendars, such as the Chinese and the Japanese ones, had to adhere to both the lunar and the solar motion — a task virtually impossible without properly established systems. Long and short months did not necessarily alternate, and the same sequence of long and short months only repeated itself once every forty-three years; the solar-based *sekki* repeated their position relative to the twelve lunar months only once every nine years; and the position of the intercalary month was based on a pattern of forty-seven years.[89] Without consulting man-made calendars it would have been impossible to remember these patterns and plan accordingly. But even with a less complex calendars that only followed the solar cycle, necessary man-made adjustments had to be made. To take a basic example, in order to know when payday, i.e. the first day of the next month, would take place, one most likely had to consult a calendar. It is thus unsurprising that the author of *Explanation of Calendrical Pointers* wrote that:

> A calendar takes the succession of the sun and the moon, and based on that, it determines the four seasons, and decides on climatic periods; it makes public the length of the day and the night, so that the people won't miscalculate the times of tilling and sowing… [The calendar] shows the weather, drought, calculates the time of tilling and sowing, and therefore it is the most valuable asset of human beings. Consequently, whatever they do, first of all people open the calendar.[90]

[89] *Wakan Sansai Zue*, fourth scroll, *Jikō rui*.
[90] Shōtei Shujin 松亭主人, *Rekijitsu chūkai* 暦日註解 (*Explanation of Calendrical Pointers*) 寛永(1848-1854), National Diet Library.

Making and Consuming Time

It is unsurprising then that the compilation of the calendar was considered to be one of the core responsibilities of the government. The regulation of time and calendrical calculations began immediately after the introduction of the temporal system and related cosmology from China. An astronomical bureau was established already in the seventh century and in the following several centuries developed into a large system that consisted of four divisions: time-keeping,[91] astronomical observation,[92] calendar compilation[93] and the hemerological interpretation[94] stating the auspiciousness of the dates according to the *onmyōdō* system.[95] The four offices were supposed to work collaboratively in order to produce calendars for every year.[96]

There were several forms of calendars and in the course of the centuries the calendar went through several transformations. By the beginning of the Edo period, a standard calendar, however, would have contained the following information: the year according to the *nengō* system of eras,[97] and also according to so called sexagenarian cycle; a one-to sixty count created

[91] *Rōkoku-hakase* 漏刻博士.
[92] *Tenmon-hakase* 天文博士.
[93] *Koyomi-hakase* 暦博士.
[94] *Onmyō-hakase* 陰陽博士.
[95] The *onmyōdō* system ("the way of yin and yang" 陰陽道), as its name suggests, originated in the ancient Chinese theory of yin/yang and the five phases. However soon after its introduction to Japan in the eighth century it began to be more and more mixed with local ancestral rites. By the tenth century, it has developed into an autonomous theory, incorporating not only the notions of yin and yang but also Daoist beliefs, Indian cosmology, Buddhist legends, esoteric Shugendō practices, and what we define today as Shintō rites. By the Edo period the system bore only general resemblance to the continental yin-yang astrology. Hayashi Makoto 林淳, *Kinsei Onmyōdo no Kenkyū* 近世陰陽道の研究 (*Studies in Early-Modern Onmyōdō*) (Tokyo: Yoshikawa Kōbunkan, 2005), pp. 72-86; Watanabe Toshio 渡辺敏夫, *Nihon no koyomi* 日本の暦 (*Japanese Calendars*) (Tokyo: Yūzankaku, 1993), pp. 21-34.
[96] *Goryaku-no-sō* 御暦の奏.
[97] According to this system, the year were counted not in one unified sequence but according to so-called eras (*nengō* 年号). The length of each era was not uniform, and could range from a few months to several decades. Only starting from the Meiji period were the eras aligned with reigns of different emperors. Prior to that, the beginning of a new era was not necessarily determined by imperial succession, but could also follow the observation of

by a combination of what is usually referred today as the ten "celestial stems," *kan*, and the twelve "terrestrial branches," *shi*, also known as the animal signs.[98] The calendar would state how many days this particular year had, which months were long (e.g., 30 days) and which ones are short (e.g., 29 days), and astronomical information such as solstices, equinoxes and eclipses. More importantly, calendars provided essential information about annual holidays, seasonal festivals, as well as divinational information for the whole year as well as for every single day in that year.

The category of "divination" was broadly defined and included both indications of auspicious and inauspicious days or directions for specific activities, as well as meteorological predictions. These were either based on interpretation of the sexageneric cycle,[99] or indicated climatic changes, such as the end of the frost hazard, beginning of the monsoons, or entering the typhoon season. Both the indication of auspicious days and the meteorological signs were

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astronomical anomalies, major earthquakes, epidemics, or result from favorable astrological calculations. The names given to those eras often included characters of positive values like "virtue" and "correctness", often combined with terms like "eternity" or "abundance". Satō, Masayuki,"Comparative Ideas of Chronology", in *History and Theory* (1991:3), p. 286.

[98] According to a legend recited in Edo period sources, such as Saitō Kakuki 斎藤鶴磯, *Shikankō* 支干考 (*Contemplations about the Shi and Kan*), 寛政五 (1793), National Diet Library, emperor Yao ordered the Yellow Emperor to create time. Observing the rhythms of the sun and the moon, the latter established the ten *kan* (干) to count days and the twelve *shi* (支) to name the months. Not unlike present day historians, Edo scholars point out that the characters 干 *(kan)* and 支 (*shi*) derive from the characters 幹 and 枝 that literally mean "tree-trunk" and "branches," and they represent the heavens and the earth. The sexagenarian cycle that combines the two system of counting into one begins with the combination of the first two signs (the *kan* of *kō* and the *shi* of *ne [rat]*), then proceeds to the combination of the two second signs (*otsu* and *ushi [ox]*), and so forth, completing the cycle with the combination of the last celestial stem with the last animal sign. If we translate this count into our own mathematical language, we can say that any combination that starts with *kō* (which is the first *kan*) will always signify a number ending with 1 (i.e., 1,11,21…51); any combination that starts with *otsu* (the second *kan*) will signify a number ending with 2 (2,12,22,..52), and so on, until finally any combination that starts with the last *kan*, *ki*, will signify a round number (10, 20, … 60).

[99] Such as a period called *Hassen* 八専, "the eight entireties," which consisted of the eight days when the *kan* and *shi* combination contained two signs of the same phase, and hence was considered to be a period of stagnation.

regarded to be the same category of "prediction,"[100] and together were considered to be were "calendrical indicators" [101] that instructed people how to manage their daily activities.[102]

The beginning of the Edo period indeed saw a sharp increase in the volume of calendar production, due to both the rapid development of print culture and the appearance of new sites of calendar compilation. The oldest sites were Kashima and Omiya,[103] but by the end of the sixteenth century calendars were also produced in Mishima, Kyoto, Nara (the so called *Nanto* calendar), Aizu, Niu, and Osaka.[104] In the beginning of the Edo period, in the first half of the seventeenth century, we see the emergence of Senshū, Ise, Satsuma, Edo (Tokyo) and Sendai calendars,[105] and later also Hirosaki, Akita, Morioka, and Tsukigashira calendars.[106]

The proliferation of local calendars in the seventeenth century caused quite a lot of confusion. Generally speaking, the system described above was supposed to be employed in each of the calendar production sites. But in reality the complexity of astronomical and astrological calculations, geographical differences, the inevitable arbitrariness of some of the decisions in the process, and local differences in the variety of parameters that had to be taken into consideration, all resulted in rather different calendars. Consequently, following the calendrical reform of the second half of the seventeenth century,[107] the shogun Tsunayoshi[108] decided to standardize and

[100] *Uranai* 占い.
[101] *Rekichū* 暦註.
[102] I am greatly indebted to Gerhard Leinss and Matthias Hayek for leading a workshop on Edo caledrical and hemerological practices, which took place in Princeton in Spring 2011. I also learned a great deal from Gerhard Leinss' existing and forthcoming writings on the topic. See Gerhar Leinss, "Japanische Lunisolarkalender der Jahre Jōkyō 2 (1685) bis Meiji 6 (1873). Aufbau und inhaltliche Bestandsaufnahme," in *Japonica Humboldtiana*, vol. 10 (2006), pp. 5−89. And "Japanische Lunisolarkalender der Jahre Jōkyō 2 (1685) bis Meiji 6 (1873). Zeicheninventar", in *Japonica Humboldtiana*, vol. 11 (2007), pp. 53−78.
[103] 鹿島、大宮
[104] 三島、京都、奈良（南都暦）、会津、丹生、大阪
[105] 泉州、伊勢、薩摩、江戸、仙台
[106] 弘前、秋田、盛岡、月頭暦
[107] See chapter three.
[108] 綱吉 1646-1709, reign 1680 -1709.

centralize the process of calendar production, creating one basic template to be used in all the Japanese provinces. The template was compiled by the astronomy office appointed by the central government and then sent to all the provinces. Licensed provincial offices then added their own "calendrical indicators" according to local conventions. The local version of the calendar was then once again sent to the capital for inspection and only then approved for distribution. Failure to follow the central template or intentional alteration of the template could result in revoking one's license; and selling calendars without a license was categorically forbidden by the central government. As a result, all of Japan came to live by the calendar compiled according to the geographical parameters of Kyoto, and the only exception to this rule was the southern province of Satsuma, that was allowed to adjust the times of dawn and sunset to its own geographical location.[109] This legislation allowed, of course, smoother communication and commerce between various provinces, but at the same time gave the central government more direct control of the provinces through the control of time. The urge to synchronize and to rule by means of synchronization was thus not unfamiliar to pre-modern rulers.[110] Yet we should also be aware of the fact that this kind of standardization was itself a convention, and it was up to different people to decide what exactly and to what degree should be standardized.

[109] Okada Yoshirō, *Kyūreki yomohon,* pp. 60-78.
[110] Stephan Tanaka in *New Times in Modern Japan* claims that this is a modern characteristic.

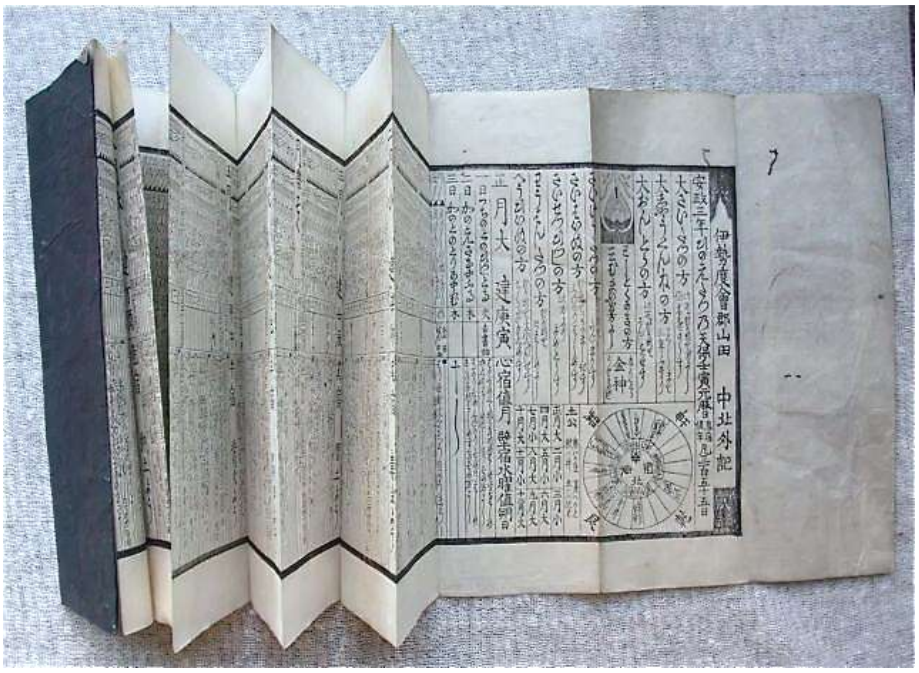

Image 1. Ise Calendar from the year Ansei 3 (1856), Author's Collection.

The calendars sponsored and distributed by the central government were only one type of calendar used by the general populace. These full-length calendars that described the quality of each and every day of the year were often bound or folded into a small book, but still were too long and cumbersome for finding basic information like the length of the current month. As a more convenient solution one could use an abbreviated version of the calendar called *ryaku-goyomi*,[111] which was only one page long and compactly presented only the most important information—which months were long or short, where the intercalary month was placed, when did the rainy season begin, etc. An even shorter version was the "big-and-small" calendar,[112] which only showed which of the months were short and which long.

[111] 略暦.
[112] *Daishō* 大小暦.

Another curious type of calendar could be found in the northeastern part of Japan. Quite remote from the main urban centers by pre-modern standards, this region was considered to be wild, exotic, and intriguing by "sophisticated" Edoites, and it was not uncommon for intellectuals to take long trips there in order to connect with nature and explore the culture and tradition of the "savage" northerners, in the same way they had explored other "exotic" cultures such as the Chinese or Dutch ones. One of those explorers was Tachibana Nankei,[113] a popular writer of the end of the eighteenth century, who had discovered that people in the northern city of Morioka used pictorial rather than written calendars.[114] Instead of writing down the length of the months, important festivals and weather predictions, all this information was encoded in pictures. Repeating previous travelers' reports, Tachibana Nankei concluded that the pictorial style was due to the ignorance of the local populace and hence referred to them as "blind calendars."[115] Nevertheless, these calendars included all the important information that written calendars contained, and they too had both extended and abbreviated versions.

[113] 橘南谿 (1753-1805).
[114] Tachibana Nankei 橘南谿, *Tōyūki* 東遊記 (*Record of Travels to the East*), sixth scroll, Waseda University online collection of Chinese and Japanese Classics (http://archive.wul.waseda.ac.jp/kosho/ru03/ru03_00323/ru03_00323_0006/ru03_00323_0006.html last accessed April 2012)
[115] *Mekura-goyomi* 盲暦. Okada Yoshirō 岡田芳郎, *Nanbu Kaireki* 南部絵暦 (*Picture Calendars of Nanbu Region*) (Tokyo: Hōsei University press, 1980), pp. 66-76.



Image 3. A "Blind Calendar," 1826, National Diet Library.

The upper row of the calendar indicated the era and the year. The era was encoded in a word play that required at least some degree of literacy. On the right we see something written— a sentence, a letter (*bun* in Japanese); then there is a man carrying on his back (*se*) the character 井 (*i*). This gives us the name of the era: Bunsei 文政. Next we see a dog, which was the animal sign of the eighth (as the number indicated by the dice) year of that era.

The short sword on the left indicated short months, and the long one on the right indicated the long (e.g., 30-day) months.

The images below indicated festivals and seasonal events, such as, for example the beginning of the monsoon season *nyūbai* 入梅, was indicated by a thief carrying away goods (on the left, below the dice for "twelfth month"); and mid-summer is indicated by a an old man striking his forehead.[116]

As Tachibana Nankei himself noted, deciphering this information was not an easy task at all, and certainly required a specific kind of pictorial literacy, which was not necessarily less complicated than the basic alphabetical *kana* style in which regular calendars were written. In addition, the pictorial style was not foreign to central Japan as well, where one too could find abridged calendars that were rendered into pictures for stylistic reasons. But more importantly,

[116] My interpretation of this specific calendar is based on the information provided by Okada Yoshirō in *Nanbu Kaireki* and *Koyomi o shiru jiten* 暦を知る字典 (A Dictionary for Understanding a Calendar) (Tokyo: Tōkyōdō, 2006). In his extensive studies, Okada Yoshirō shows how complicated the language of calendars was, regardless of the format.

many names were encoded in word, character and sound-play, so that in order to understand the pictorial hint, one had to have some knowledge of written characters. Consequently, it is much more likely that the pictorial style of the northern provinces was the result of local convention rather than illiteracy.[117] Nevertheless, for the purpose of this chapter, it is important to stress that even regions that were considered to be "savage" by contemporary urban dwellers relied heavily on calendars and were aligned with the centralized time-management system.

So how many calendars, of all kinds, were out there? According to Watanabe Toshio, every household should have received at least one calendar each year.[118] Along the same lines, Okada Yoshirō argues that in the late Edo period around four and a half million copies of official calendars were published each year. With a population of around twenty-seven million, this meant that there was about one official distributed calendar for every four people (including small children).[119] Both scholars agree that the number does not include the abbreviated *ryaku-goyomi* calendars, pictorial calendars, local *kawaraban* news-boards that published full or partial calendars, and, of course, all the pirated, illegally sold versions. Indeed, even the risk of severe punishment did not deter those who identified an economic opportunity in calendar-making, answering the needs of a highly demanding market. Taking into account all of the above, it would be quite safe to say that many people probably owned several calendars, some of which were specifically designed to be carried around.

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[117] In "Literacy Revised: Some reflections on Richard Rubinger's findings," *Monumenta Nipponic*a, vol. 56, No. 3 (Autumn, 2001), pp. 381-395, Peter Kornicki stresses that (il)literacy cannot be inferred from the lack of writing in certain documents.

[118] Watanabe Toshio 渡辺敏夫, "Edo jidai no rekihon hankō sū 江戸時代の暦本版行数" ("The Number of Calendar-Issue in Edo Period ") in *Wadokei Kenkyū* 和時計研究 (*Journal of Japanese Clocks*) vol. 6, num. 1, (1992), pp. 15-24.

[119] Okada Yoshirō, in *Kyūreki no yomihon*, p. 61.

To exemplify how common calendars were, at least in the latter part of the Edo period, we can simply look at the number of old calendars available for sale in used bookstores today. Since calendars could only be used for one year, and there was no practical need to keep old ones for accounting or any other purpose, masses of old calendars were thrown away or recycled at the beginning of each year. Indeed the expression "old calendars" (*furugoyomi*) became an epitaph for things (or even people) that nobody wanted or needed any longer. Seeing that these were not valuable things to be kept, the fact that we still find them in large quantities today, and given that they had to survive not only intentional disposal but also fires, wars, humidity, and bookworms, indicates that they were probably available at much larger numbers at the time.

Working Hours

The sheer number of these calendars, as well as the amount of effort that was invested in producing and distributing the calendars, illuminated the importance of time management at the level of years, months, and days. But what about the time management of a day? Did Edo period Japanese care about knowing and managing the hours? The variable length of the hours, their dependence on the timing of dawn and sunset, the fact that the numbers associated with them were not quantifiable,[120] and twelve animal signs count—all these facts fit the classic descriptions of "concrete" time in pre-modern, pre-capitalist societies.[121] According to the classic historiography of time, the variable hours differ from the modern, "abstract" ones in the sense that they were by definition task-oriented and therefore not interchangeable; that they could not dictate the periods of work and leisure; and that they served agrarian societies that lived

[120] Namely, the first hour after noon was not 1 but 9, and third hour after noon could not be calculated as 9 (noon) +3.
[121] E.P. Thompson, "Time, Work-Discipline and Industrial Capitalism"; Moishe Postone, *Time, Labor, and Social Domination: a Reinterpretation of Marx's Critical Theory*; David Landes, *Revolution in Time.*

according to natural cycles. In short, according to these theories, there was no time-tyranny over workers and time was not "labor time"; time didn't equal money since the notion of productivity as output per time-unit was not in place. If we accept these claims, we might think that Edo Japanese didn't need clocks because they simply didn't need to measure time, living only according to natural cycles, or just observing the length of the shadows. This link between undetermined hours and the pre-capitalist mode of time management becomes questionable, however, when we look closely at the time management structures and work patterns of Edo period Japan.

The easiest link to negate is that between variable hours and agrarian societies. By the year 1700, Edo (Tokyo) was already populated by over a million people, one of the largest cities in the world at the time. And although other large cities such as Osaka, Kyoto and Nagoya did not reach this size, they were still much larger than any European city of that time. Yet clearly these urban masses saw no problem in using variable hours.

Nor did variable hours pose any problem for work schedules. Indeed, it was common to say that people worked "six to six", namely from dawn to sunset.[122] Yet in reality people were very much aware of the fact that "six to six" in the winter meant a different amount of time than during the summer. Consequently, working schedules were adapted to the seasons, so that during the summer people would leave for work around the fifth (dragon) hour of daytime, while during winter they would start already in the seventh (tiger) hour of nighttime, so that eventually they worked about the same amount of time throughout the year.[123] A collection of legal documents from the Edo period describes smiths whose work contract strictly defined the working hours in

[122] In Japanese, *ake mutsu* (the sixth hour of dawn) to *kure mutsu* (the sixth hour of sunset).
[123] Tsunoyama Sakae 角山栄, *Tokei no shakaishi* 時計の社会史 (*The Social History of Clocks*) (Tokyo: Chūkō Shinsho, 1984), p. 114.

each season. On the other hand, the same contract also stated that the worker will have a day off on every first, eighth and fifteenth of every month, as well as during the general holidays.[124]

In general, people were paid by the day, yet this length of the "workday" was defined by the contract and not by the cycle of dawn and sunset. Moreover, some of the contracts indicated that if a worker had worked more than what was defined as a working day he would be eligible for an overtime wage, calculated on an hourly basis plus ten-percent of an hour for every additional hour.[125] Neither were employers too lax on tardy workers. As Morishta Toru tells us, something not unlike a punch-card system was used, in which people had to stamp their personal seal in the beginning and end of every workday in order to receive pay for that day.[126]

Agrarian regions too were quite aware of the fact that time equals output. Tsunoyama Sakae raises the story of a dispute that broke out between three different villages over the amount of irrigation water each received. Following a lawsuit, the court decided that water would be distributed by the hours: from the hour of the dog to the hour of the tiger the water would be diverted to one village; from the hour of the rabbit to the hour of the sheep to the second; and during the remaining hours to the third.[127] The judge and the plaintiffs were thus well aware of the fact that time equals the amount of water provided, and even though neither the signs of hours nor their numerical representations were quantifiable,[128] they did not have any problem doing the mathematics. Here we have a clear case of a quantitative division of goods being

[124] Ministry of Justice Research Dept. ed. 司法省調査課編, *Tokugawa minji kanreishū* 徳川民事慣例集 (*Collection of Tokugawa Popular Costumes*), vol. 5 *Soshō no bu* 訴訟の部 ("Litigations") (Tokyo: Tachibana Shoin, 1986), p. 113-115.
[125] Morishita, Tōru, "Time in Early Modern Local Community," in *Japan Review* number 14, 2002, special issue *The Birth of Tardiness: The Formation of Time Consciousness' in Modern Japan*, p. 75.
[126] Morishita, Tōru, "Time in Early Modern Local Community," p. 72.
[127] Tsunoyama Sakae, *Tokei no shakaishi*, p. 110.
[128] Namely, the 8 of the hour of the sheep minus the 6 of the hour of the rabbit will not provide the answer "5" – the amount of hours that actually passed.

translated into a time division, which in turn created a certain time-based social order (the irrigation of the fields, etc).

And in the same manner as the variable hours were not in any sense an obstacle for quantification, they also didn't prevent anybody from aspiring to make a profit. It is true that in the Edo period the slogan "time is money,"[129] which was popularized during Meiji, was not yet in use. But this does not mean that time was not considered an important factor in profit-making. T. C. Smith points out the importance of scheduling in peasant instructional literature, with slogans such as "plan for the year in the first month, and for the day in the morning." Smith also describes how the peasant ideologue Ninomiya Sontoku[130] advocated the proper use of time and planning ahead, while one of his followers created a "working schedule" for peasants.[131] Thus, the idea that a waste of time is a waste of money was certainly not foreign even to the agrarian strata of Edo Japan.

Being aware of the hour of the day was a well-recorded form of time consciousness one finds in letters and diaries of the period. Already at the end of the sixteenth century, Pere Charlvoix wrote in his *Historie du Japon* that "the Nipponese have a great need to mark in their history, not only the day on which events occurred, but even the hour and the part of the hour."[132] Sora,[133] who accompanied the famous Haikai poet Matsuo Basho[134] in his travels,

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[129] Nishimoto Ikuko, *Jikan ishiki no kindai: "toki wa kane nari" no shakaishi* 時間意識の近代:「時は金なり」の社会史 (*Time-Conscious Modernity: a Social History of "Time is Money*") (Tokyo: Hosei University Press, 2006).
[130] 二宮尊徳 (1787-1856).
[131] T. C. Smith, *Native Sources of Japanese Industrialization, 1750-1920* (Berkeley, CA: University of California Press, 1988), p. 203- 219.
[132] Cited in Silvio Bedini, "Oriental Concepts of the Measure of Time," in *The Study of Time II* (Berlin: Springer-Verlag, 1975), p. 454.
[133] 曾良 (1649-1710).
[134]芭蕉(1644-1694).

provided an hour for each entry and event mentioned in his diaries.[135] Takahashi Satoshi provides the story of Yūyama Gin'emon, who recorded in his diaries the hour in which he left his house, arrived at certain places, how much time was spent eating and drinking, and also noted when things did not go according to his planned hourly schedule.[136]

It is true that Edo period people did not wear watches and could not tell if they were off schedule by five minutes, but the concern for doing things on time and not being late[137] was nevertheless very real for them, as tardiness was a punishable offence.[138] The gates of castles, temples, and mines were open and closed exactly on time, and nobody wanted to be left out or locked in. Certain temples required pilgrimages to be made no later than a certain hour in the morning, and women were instructed not to walk alone on the streets after a certain hour in the evening. The times of births were scrupulously registered, up to an exact *bu* division of an hour.[139] The variable hours system neither determined these concerns with time, nor limited them; rather specific temporal practices evolved throughout the Edo period *within* the conventional structures.

The Sound of Time

But how did people know when it was time to be "on time"? When we look at contemporary documents and diaries it is clear that throughout the period people knew what hour

[135] Matsuo Bashō 松尾芭蕉, *Oku no hosomichi* おくの細道 (*The Narrow road to the Interior*), with addendum of Sora's travel diaries *Sora tabi nikki* 曾良の度日記 (Tokyo: Iwanami Bunko, 2004).
[136] Takahashi Satoshi 高橋敏, *Edo no soshō* 江戸の訴訟 (*Edo litigations*) (Tokyo: Iwanami Shoten, 1996).
[137] A term that we commonly see in Edo period is "to overdue the time" 時刻を遅る.
[138] Collection of documents from Kaga Domain mentions a case from 1798 when a person was punished for being late from his trip to Edo. Watanabe Makoto 渡辺誠, *Kanazawajō jōshō no yakuwari to jikokuseido no hensen* 金沢城城鐘の役割と時刻制度の変遷について ("On the Tranformaitons of Time Systems and the Role of the Castle Bell of Kanazawa Castle"), in *Edo no Monodukuri* 江戸のモノづくり (*Artisanship of Edo period*) (Tokyo: Seika Hōkoku, 2006), pp. 51-69. See especially p. 59.
[139] Tsunoyama Sakae, *Tokei no shakaishi*, pp. 109 -113.

of the day it was. The system that allowed them to be constantly and even involuntarily aware of the time was a network of public time-telling bells and drums.

Announcing the time by bells was by no means unique and certainly far from new in Edo period Japan. Several time-telling bells were cast immediately after the introduction of the Chinese temporal system in the Nara period (710-794), and temple bells were used to announce hours throughout the Kamakura (1185-1333) and Muromachi (1333-1573) periods. The novelty of the Edo period time-telling system was in its vast scope and in the fact that it was a government-sponsored public system that was built in order to serve the needs of the general populace. Some of the new time-bells were still located in temples, but they were distinguished from bells that were used for religious purposes. To stress the difference between those time-telling bells and the temple bells, which rang only six times a day, the first were called "2X6 time-bells," since they rang on each of the twelve double-hours.[140]

The development of new mining techniques and the rising availability of metals during the sixteenth century also played a role in this process, allowing for even relatively small and poor communities to afford time-bells.[141] But we should also bear in mind that time was not only announced by bells but sometimes also by huge drums,[142] and hence the expansion of the public time-telling system cannot be attributed to the availability of metals alone.

The bells (and sometimes drums) were installed into open towers that allowed the loud sound to be carried over long distances. Referred to as "time-bells,"[143] they were a familiar sight in the Edo landscape, and one often sees them in old maps and paintings. They began to appear

[140] Urai Sachiko 浦井幸子, *Edo no jikoku to toki no kane* 江戸の時刻と時の鐘 (*Edo Time System and Time Bells*) (Tokyo: Iwata shoin, 2002), pp. 36, 173.
[141] Tsunoyama Sakae, *Tokei no shakaishi*, p. 71.
[142] *Taiko* 太鼓.
[143] *Toki-no-kane* 時の鐘.

already in the seventeenth century, in the beginning of the Edo period, and by the beginning of the eighteenth century there was no place in the urban areas where their sound could not be heard.[144] In fact, their number and density was such that inevitably their sound began to overlap with each other. To eliminate confusion, the ringing of the bells had to be at least somewhat synchronized, which was indeed effectively done by municipal authorities.

The Russian navy captain Golovnin, who was held captive in Japan between 1811-13 in the northern province of Matsumae, describes the striking of the time-bells thus:

> The Japanese strike the hours in the following manner: first they strike the bell once, then after about a minute and a half they strike twice, one strike right after the other; those three strikes announce that the hours are about to be struck, as if they were saying: listen! Then, after another minute and a half they start to strike the hours, strike after strike in intervals of some fifteen seconds, but the last two they strike quickly one after the other, as if to indicate: enough counting![145]

Looking at this network of public time-bells, and the way their sound was intertwined with daily temporal practice of people from various social strata, it is no longer possible to focus only on the outline of temporal structures as a representation of Edo time-consciousness. This example clearly points out that in order to grasp the sense of what was it like to live according to the Edo period temporal system, it is not enough to analyze the structures, but rather, it is necessary to look into the actual practices involved in following these structures, and to touch upon the "matter" time was made of.

Conclusion

[144] Some sources claim that in the end of the seventeenth century there were about thirty thousand bells in Japan. See for example Hirai Sumio 平井澄夫, *Tokei no hanashi* 時計のはなし(*The story of the clock*) (Tokyo: Asahi Shinbun Shuppan, 2001), p. 114.

[145] Vasiliy Michailovich Golovnin *Zapiski flota kapitana Golovnina o prikliyucheniiakh ego v plenu u iapontsev v 1811, 1812 i 1813 godakh, s priobshcheniem zamechaniĭ ego o Iaponskom gosudarstve i narode*, (The diaries of the captain of the Russian fleet, Golovnin, about his adventures in Japanese captivity in the years 1811, 1812 and 1813, together with his general comments about the Japanese state and its people) (Khabarovsk: Khabarovskoe knizhnoe izd-vo, 1972), p. 215.

Temporal order is undoubtedly one of the major factors that shape any community. Yet we ought to ask ourselves what does a "temporal order" include. The basic temporal categories are the very first aspect we usually notice about foreign "time." Yet those characteristics usually have a very long history that stretches not only over time but also over various geographic regions. It is precisely the longevity of temporal categories that points to the fact that they are not reflections of a collective psyche but rather conventions.

This is not to say that we should dismiss them as "mere" conventions, for those conventions effectively shaped some of the basic structures around which social practices were built, even when they were no longer connected with their original meanings. They are akin to the foundations that determine the overall layout of a house but have no power to dictate what life its inhabitans lead. And it is precisely this evolving life, the content that filled the conventional structure that can truly be regarded as the temporal order.

Japanese temporal order changed throughout the Edo period. Whereas in the very beginning of the period there were only a few public time-bells, by the end of the eighteenth century the country was covered with them, and even the most remote places and small villages had a public time-announcement system. Calendars that were quite uncommon and highly valued in the beginning of the seventeenth century could be seen everywhere in the nineteenth century. Work schedules became more detailed and more precise in their temporal instructions. People began to notice smaller and smaller divisions of the hour and there was more and more concern about precisely defining those units. The temporal order on the verge of the Meiji reformation was very different from that of the beginning of the Edo period. Therefore, instead of regarding the temporal order of the Edo period as stagnant, and as having to undergo an epistemic break in order to become the modern time of Meiji, we should rather see here a series of differences in

degree, scope, configurations of daily schedules, changes in the material basis of the temporal order, the rhetoric surrounding time, and the rhythm of temporal practices.

The same could be said about time-consciousness. Although during most of the Edo period people did not carry watches that could measure minutes and seconds, nor did they have to catch trains leaving on the minute, we cannot deny them time-consciousness simply because they were not punctual by *our* standards. Punctuality is obviously a relative term. To be punctual is to abide by a range of temporal approximations determined by existing social norms, and in this sense, we can say that Edo people too could be punctual or not punctual relative to their standards. They too found it important not to be late for certain things, and thus had to rely on aids such as calendars, public time-bells and, as we shall see in what follows, other kinds of timekeepers as well.

Chapter 2: What's ticking? The Evolution of Edo Timepieces

The Arrival of Mechanical Clocks

The year 1551 was the first time a mechanical clock was seen on Japanese soil. It was brought by the Jesuit Francis Xavier,[146] and presented as a gift to Ōuchi Yoshitaka,[147] the Lord of Yamaguchi, in gratitude for allowing the opening of a Christian mission in the province.[148] News of the fascinating object spread, and the Jesuits reported that they were asked more and more about the device that could strike the hours without the touch of a human hand. A decade later, the most powerful warlord in Japan at the time and a big admirer of everything Western, Oda Nobunaga,[149] sent for another Jesuit, Louis Frois, demanding to see a clock— an "alarum". After his curiosity was satisfied, however, Nobunaga said that "although he liked it, he did not want it because it would be useless in his hands".[150]

Yet, despite the fact that the latest European technology was considered to be useless in Japan, more and more clocks were brought to Japan as expensive gifts.[151] And even after the

[146] St. Xavier (1506-1552).
[147] 大内義隆 1507-1551.
[148] This clock has not survived to the present day, but both the Jesuit accounts and the records of Lord Ōuchi Yoshitaka mention such a gift. Ryuji Yamaguchi cites from Jean Crasset's *Historie de l'Eglise au Japon*, written in the mid seventeenth century, where "Une petit Horologe Sonante" is mentioned. In Ryuji Yamaguchi 山口隆二, *Nihon no tokei* 日本の時計 (Japanese Clocks), (Tokyo: Nihon Hyōronsha, 1942), p. 11; Tamura cites the Japanese translation of Louis Frois's *Historia de Japam* written in the end of the sixteenth century. In Tamura Takeo 田村竹男, *Ibaraki no tokei* 茨城の時計(Clocks of Ibaraki) (Tsukuba: Furusato Bunko, 1990), p. 121. Both Yamaguchi and Tamura cite the same passage from the records of Lord Ōuchi Yoshitaka (大内義隆記).
[149] 織田信長.
[150] Michael Cooper *They came to Japan; an anthology of European reports on Japan, 1543-1640* (Berkeley: University of California Press, 1965), "*alarum"*p. 96.
[151] Another clock was presented by the head of the Jesuit mission in the Far East, Alessandro Valignano (1539-1606, official title is "Visitor of Missions in the Indies") to the ruler of Japan, Toyotomi Hideyoshi (豊臣 秀吉 1536-1598) in 1591 and in 1606, João Rodrigues presented another clock to the first Tokugawa shogun, Ieyasu (徳川 家康 1543-1616). None of these clocks has survived to the present, but we do have a clock from this period, one that was brought to Japan by the returning Japanese Christian mission to Rome. The mission passed through Mexico, or

Tokugawa house banished the Jesuits, and limited *any* foreign presence in Japan to tiny compounds, the clocks were still used as an important political gift. English and later Dutch merchants started bringing more and more clocks and pocket watches, both for the purpose of gift-giving and, as the interest in them grew, for sale.[152] The records of the VOC[153] show that the flow of clocks and watches constantly increased, and that they were considered to be a merchant's "safe bet" even during years of economic depression.[154]

Seeing that clocks are sometimes taken to be revolution-provoking devices in the European context,[155] one might expect that the same kind of structural and social change should have happened in Japan as well. Yet this was not the case. Instead it was the clocks themselves that were altered, transformed and made fit to contemporary Japanese standards. They were shaped to answer Edo consumers' desires, creating a category retrospectively called *a Japanese clock –wadokei.* [156]

In the course of the more than two hundred-fifty years of the Edo period, Japanese clockmakers produced not only larger and larger quantities of clocks, but also a wide range of clock types, which varied in size, function and mechanical structure, as well as external appearance. Why did the Japanese consider European clocks to be useless as they were, and what was considered to be useful instead? What were the forces that drove the evolution of Japanese

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Nueva España as it was then called, and was given a clock by its Governor to be presented to the Japanese "king". Yamaguchi, *Nihon no tokei*, pp. 15-16.

[152] Yamaguchi, *Nihon no tokei*, pp. 18-19.

[153] *Vereenigde Oostindische Compagnie* - Dutch East India Company.

[154] Martha Chaiklin, *Cultural Commerce and Dutch Commercial Culture: the Influence of European Material Culture on Japan, 1700-1850* (Leiden: CNWS, 2003).

[155] For traditional accounts on European horology see the following: David Landes, *Revolution in Time* (Cambridge, Mass: Belknap Press of Harvard University Press, 1983); J.T. Fraser ed., *The Voices of Time*, (NY: George Braziller, 1966); Jacques LeGoff, *Time, Work & Culture in the Middle Ages*, Arthur Goldhammer, trans. (Chicago: University of Chicago Press, 1980); A.J.Turner, *Of Time and Measurement* (Brookfield, VT : Variorum, 1993).
A more updated account, devoid of technological determinism, can be found in: Gerhard Dohrn-van Rossum, *History of the hour: clocks and modern temporal orders*, Thomas Dunlap, trans. (Chicago: University of Chicago Press, 1996).

[156] 和時計

clocks, and what factors shaped the specific forms clocks assumed? And what can we learn from this process of adaptation about Edo period perception of time measurement, timepieces and the time itself?

Interaction of artifacts with societies that created them was always considered to be one of the most fundamental, but at the same time most difficult questions in the history of technology, the reason being the fact that we can only observe technologies *in* societies, inseparable, developing alongside each other. From this perspective, we can treat the case of Japanese clocks as a naturally occurring historical experiment that provides us with the necessary conditions where technology taken out of the society that created it, and transplanted into another social and cultural context. Just several decades of Jesuit activity with only a handful of clocks available were not enough to transmit to Japan cultural values associated with timekeeping and timepieces in the West. Equally, the clocks that were imported in seventeenth and eighteenth centuries did not come with cultural guides that instructed how to approach, view and use them. It was up to Japanese users to come up with their own interpretations of physical structure they had in hand, employing their own habits of dealing with artifacts and relying on their own arsenal of temporal and technological associations. Let us examine then, the process by which European clock-making technology underwent alternative treatment by Japanese users, assumed new meanings, and came to be associated with new practices.

Things That Count Time

So how did Japanese measure time? At the end of his treatise on the origin of the hour count, the author of *The Numbers of the Twelve Hours of Bells and Drums* provides a humorous list of various possible ways to keep time, disclosing the reasoning behind the intriguing alternative title he gave to his book: *The Twelve Hours of Bells and Drums, and a Nose Clock.* In a scholarly fashion of referring to the authority of ancient Chinese Daoist texts,[157] he jokingly suggests that one can know the time by looking at people's noses: during the *yin*, namely odd, hours, noses tend to slightly bend to the left, and then they turn to the right during the *yang* hours. Or, he continues, based on the fact that humans breathe exactly one thousand one hundred twenty-five times a day, one could simply count one's own breaths. If nothing else is available, one could also guess the hour by looking at the size of a cat's eye. However, the author suggests teasingly, those who seek less exotic methods can also measure time by looking at the stars, or by using clepsydras, sundials, hourglasses, astrolabes and "other" things that he chooses to omit due to their apparently "lengthy explanation."[158]

The first recorded man-made timepiece in Japanese history was a water-clock, a clepsydra.[159] The clepsydra was clearly employed during the Nara (710-794) and Heian (794-

[157] *Sanji zhiming quanti* 三極至命筌蹄 (The three Ultimates and the Supreme Destiny Ensnared), written after 1244 by Wang Qingshen 三極至命筌蹄; *Xishang futan* 席上腐談 (Learned Talk around the table), written around 1326-1327 by Yu Yan 俞琰.

[158] Anonymous, *Jūniji shōko no kazu* 十二時鐘鼓之数 (The Numbers of the Twelve Hours of Bells and Drums), or *Jūniji shōko narabini hana dokei* 十二時鐘鼓並鼻時計 (The Twelve Hours of Bells and Drums, and a Nose Clock), Kyōhō 15 (1730) copy, original date unknown, Tokyo National Museum Archive.

[159] The earliest recorded man-made timepiece in Japanese history is found in eighth-century historical chronicle, the *Nihon shoki* 日本書紀. There, it is mentioned that in the sixth year of the reign of emperor *Saimei* (660 AD), "*Hitsugi-no-Miko* built a "clepsydra for the first time, to let people know the time". Then, "on the first day of the fourth month of the tenth year of emperor's Tenchi reign (671 AD), clepsydra was placed on a platform, and by setting drums and bells in motion, it struck the hours for the first time". Sakamoto Tarō et. al ed., *Nihonshoki* (Tokyo: Iwanami Bunko, 1995), vol. 4, p. 358, and vol. 5, p. 56, respectively. These two passages are probably the

1185) periods, but the wars that preceded the beginning of Kamakura period (1185-1333) were destructive for this timekeeping device and the public time-telling practice was discontinued.[160] Some local versions of this device must have survived, since we see mention of such a device in Louis Frois' account of Japan.[161] An illustration of a *rōkoku* also appears in Phillip Franz von Siebold's *Nippon,*[162] written in the early nineteenth century;[163] although the image in Siebold's book looks so similar to the images in Japanese books of that time, that one is tempted to suspect that he might never have seen the real device, but rather copied such an illustration.[164]

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most famous in the history of Japanese horology, and there is almost no present-day historian, nor Edo period scholar writing about the origins of time in Japan, who failed to mention them. Sources such as *Wakan san sai zue*, *Jūniji shōko kono sū, Rōkokusetsu*; Anonymous, *Tokei zu* 時計図 (Illustrations of clocks), date unknown, Tokyo National Museum Archive; *Sokuryō sho ki zu* 測量諸器図 (Illustrations of Various Measuring Devices), National Astronomical Observatory of Japan Archive; and others, all cite these passages.

[160] Satō Masatsugu, *Rekigakushi taizen,* p. 200.

[161] Hirai Sumio, *Tokei no hanashi*, p. 25.

[162] Philipp Franz von Siebold 1796-1866, in Japan 1823-1829.

[163] Von Siebold, *Nippon, Archiv zur Beschreibung von Japan*; v*ollständiger Neudruck der Urausgabe zur Erinnerung an Philipp Franz von Siebold erstes Wirken in Japan, 1823-1830, in zwei Text-und zwei Tafelbänden, dazu ein neuer Ergänzungs- und Index-Band von Dr. F.M. Trautz; herausgegeben von Japaninstitut Berlin*, (Berlin : E. Wasmuth, 1930-31), Atlas, vol. I, p. 210.

[164] See for example *Sokuryō sho ki zu* 測量諸器図 (Illustrations of Various Measuring Devices), National Astronomical Observatory of Japan Archive. The NAOJ database lists this work as written by "anonymous", but Watanabe Toshio identifies the author as Nishimura Tōsato. (See Watanabe Toshio, *Kansatsu gijutsushi* (History of the Art of Observation), (Tokyo: Kōseisha Kōseikaku, 1987), p. 556.

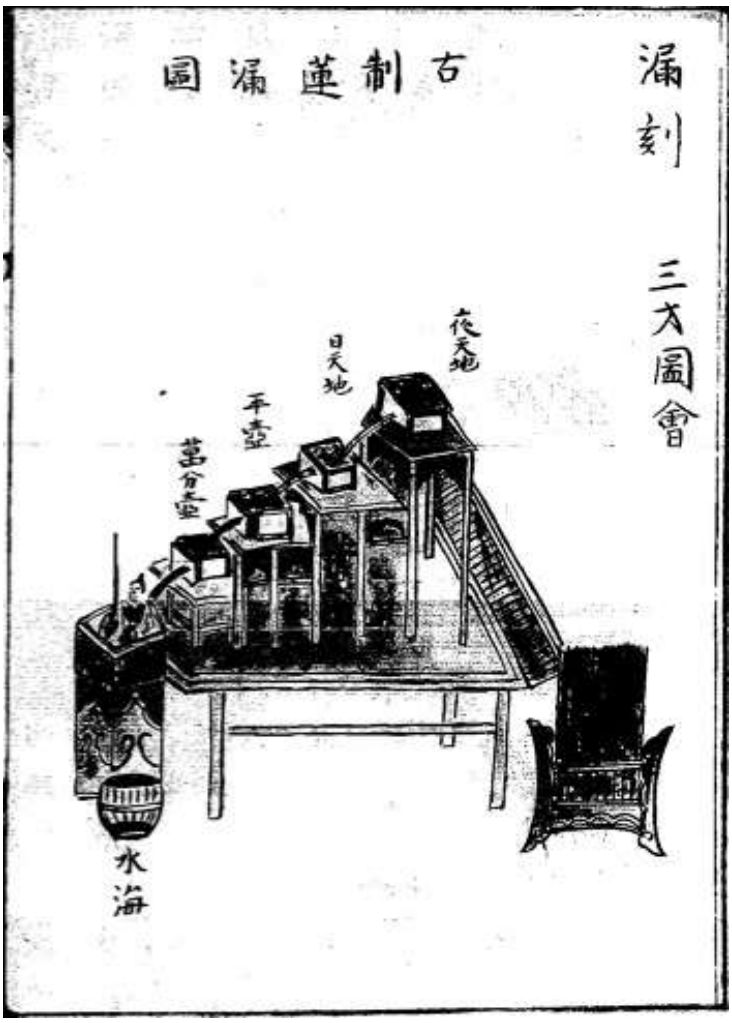

Image 4. *"Rōkoku"* from the 18th century *"Illustrations of Various Measuring Devices."* National Astronomical Observatory of Japan.

According to Edo-period sources, this device consisted of four vessels, with water flowing from one to another in order to ensure a steady flow. In the fifth, bottom vessel there was a figurine with an arrow in its hand, floating on the surface of the water. The tail of the arrow was marked with hundred notches, and by observing which notches were visible above the top edge of the vessel it was possible to know how many "notches" passed since the midnight, namely what the hour was.[165] The name of the device reflects its structure: written with the two characters "dripping" (*rō* 漏) and "notches" (*koku* 刻) it referred to both the method of measurement and the measurement units. The practice of counting the "notches" was carried on even when clepsydras were not in use anymore, and the hundred units the day was divided into were referred to as *koku* — notches.

[165] Shibukawa Kagesuke 渋川景佑, *Korōsetsu* 壺漏説 (Explanation of the ater clock), cited in Hirai Sumio　平井澄夫, *Tokei no hanashi* 時計のはなし (The story of the clock) (Tokyo: Asahi Shinbun Shuppan, 2001), p. 101

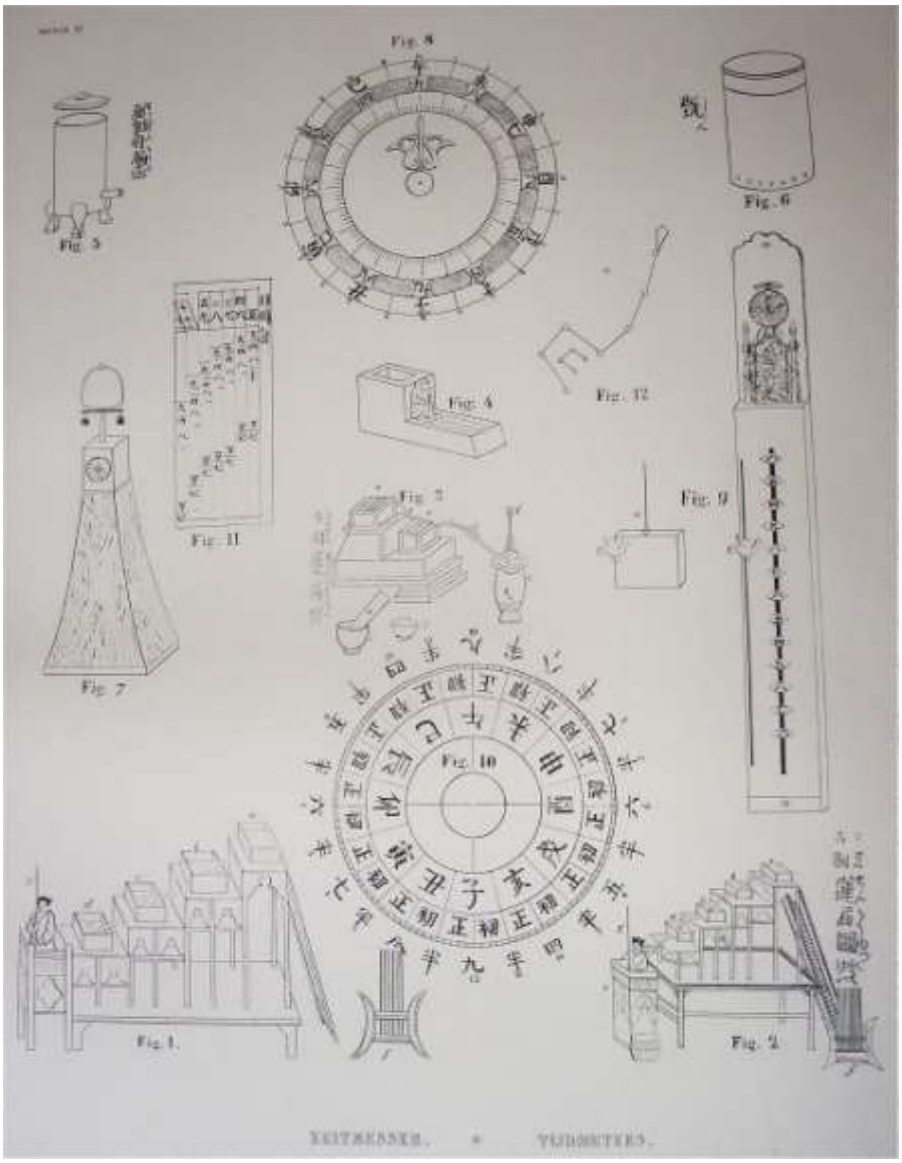

Image 5. Depictions of Japanese timepieces in Philip Franz von Siebold, *Nippon*. Princeton University Rare Books Collection.

Figures 1 to 6 all depict clepsydras or "steam clocks" found in Japanese writings of Edo period. The depictions are practically identical to those found in Edo period text titled *Illustrations of Various Measuring Devices* and the reader can compare Fig. 2 to the illustration above.

Note also Fig. 7 and 8 that portray mechanical clocks that would be discussed later in the chapter. Fig. 8 depicts a round dial of the Japanese mechanical clock of Fig. 7

Note also Fig. 11 that depicts a portable paper sundial popular during the Edo period that will be discussed later in the chapter.

In fact, the water clock described in Edo-period sources also looks very much like the one depicted in the Song period (960-1279) Chinese encyclopedia *Vast Records of the Matters Forest*,[166] even using the same terms when describing various parts of the device.[167] Furthermore, some Edo-period authors explicitly mention that this was an ancient method of time reckoning, which was no longer in use.[168] What complicates the story of water clocks even more is the fact that they measured time in equal units, not the variable ones used for everyday time reckoning. [169] Thus it seems that although famous, the water clocks were not widely used in Edo period.

Another device that probably occupied mostly imaginary space was a sand clock.[170] This sand clock was not at all similar to the Western hourglass; rather it was supposed to be a variant of a clepsydra with sand replacing the water flow from vessel to vessel. Although mentioned in several writings[171] as one of the possible methods of keeping time, the sand clock nevertheless was not featured in documents that dealt with the actual use or production of timepieces, and neither do we have any exemplar of anything resembling such a device. The closest mentioning to the actual use of the sand clock was an entry in an early eighteenth century book.[172] There, the sand clock is described as a series of vessels with a mechanical monkey hanging from them and allowing the flow of sand from one vessel to another. The book does not provide any detail about

[166] Chen Yuanjing 陳元靚, *Shi lin guang ji* 事林廣記.
[167] Joseph Needham, *Science and Civilization in China*, (Cambridge: Cambridge University Press, 1959) vol. 3, pp. 323-4.
[168] Anonymous, *Tokei zu* 時計図 (Illustrations of clocks), date unknown, Tokyo National Museum Archive.
[169] Equal units of time were used for astronomical purposes. Astronomical timepieces will be discussed in length later in this study.
[170] 砂時計.
[171] See for example the above mentioned *Jūniji shōko kono sū* and *Sokuryō sho ki zu.*
[172] Fujii Kenryū 藤井見隆, *Shūgyoku shin chie no umi* 拾玉新智恵海 (*Discovered Jewel of New Sea of Wisdom*), 享保九 (1714). Tokyo University Archive.

its construction or use, and generally reads as a commercial for the automata performances, leaving the reader to guess whether the devices described there were not just imaginary.

Instead, there was another, more compact method of measuring time – by using incense or candle sticks. [173] Both incense and candles were in widespread daily use, and both burned at a steady enough rate, necessary for measuring time. Both were fairly easy to adapt to the variable hours system: sticks of candles or incense of different lengths could be used during different seasons.[174] Incense had an advantage, though, in that it was relatively safe because it did not produce a flame. There were also fixed incense timepieces in the form of incense-boards, *jikōban*,[175] best described by the Russian Capitan Golovnin, who was captive in Japan from 1811 to 1813:

"[a] relatively small wooden block, covered with clay and whitened; in the clay a narrow ditch is drawn, and filled with powder made of some kind of grass, which burns very slowly, and on the sides of this ditch there are holes into which one inserts a nail; near those holes there is a designation of the length of day and night hours during the six months from the spring to autumn equinox; during the other six months, the day hours become the night ones and vice versa. Thus, the Japanese clock masters find the length of the day hour in a certain period, mark it with the nail and, filling the ditch with powder, they set it alight at noon, and in this way they measure time. This wooden block they keep in a closed box and try to store it in a dry place..."[176]

But an even more basic device for measuring time was the sundial. Noting the time by observing the daily movement of the shadows is perhaps the most ancient form of timekeeping, and humans in many cultures learned how to utilize this movement for their purposes. For relatively accurate measurements, relying on the movement of the shadows proved to be a tricky

[173] *Tokei no hanashi*, p. 26.
[174] Silvio Bedini, *The trail of time – Shih-chien ti tsu-chi: time measurement with incense in East Asia* (Cambridge & New York, Cambridge University Press, 1994). Bedini also mentions that different fragrances could be used to mark different hours. In this case one becomes aware of the passage of the time by the sense of smell.
[175] 時香盤.
[176] Golovnin, *Zapiski Kapitana Flota Golovnina*, p. 214.

task – the shadow's edge was fuzzy, and during the winter it was too short and moved too slowly to allow any kind of measurement at all. Nevertheless, unless one has to measure time units as small as one-hundredth of a day, one could use a relatively small sundial for an approximate indication of time. Another potential complication with sundials was that in order to be able to tell the time they should be north-south aligned. The position of astronomical gnomons was of course carefully calculated, but it obviously created a problem for those who wanted a portable timepiece. But here again the solution was quite easy – portable sundials were simply supplemented with a small compass.

Unlike the famous clepsydra, the history of the introduction of sundials to Japan is quite obscure. Nevertheless, inventories from the seventeenth century[177] show that by the beginning of the Edo period, gnomons, stationary and portable sundials were certainly in use. Moreover, it seems that with the increasing availability of time-telling bells in the beginning of the Edo period, the use of portable sundials became more and more popular. Some of the sundials were made of ornamented brass, or carved wood, and others were simply made of paper and adapted to measure the changing length of hours.

It is quite possible that these ancient forms of time-keeping were the source of the modern day Japanese word for a clock or a watch – *tokei*. Modern day characters of this word are 時計, meaning simply "measuring time." This combination, though, appears to be extraordinary, since in no other word is the character 時 read as *to*. Whatever true reason for this unusual combination, Edo period scholars certainly thought it was superimposed on a more ancient sound, and hence another meaning. Therefore, although the combination 時計 can be seen

[177] Two sundials are mentioned in a record from 1616 describing the timepieces left by the first Tokugawa shogun Ieyasu after his death. Hirai Sumio 平井澄夫, *Taiyō no hari* 太陽の針 (The index-hand of the sun), in *Wadokei Kenkyū* (Journal of the Wadokei-Gakkai), 1, June 1992, p. 30.

already in sixteenth century documents, many authors point out that *tokei* is in fact a 土景 — "earth-shadow", or 土圭 — "earth-gnomon", a term used in Chinese sources as well. [178] These are by no means the only combinations of characters seen in Edo-period texts - one can also encounter a 斗計 "measuring the Big Dipper"; a 土卦 "earth – [an Yi jing] trigram"; or even a 時規 "regulating time" that does not match the phonetic expression either. It is not clear whether this way of writing reflects a historical etymology or, perhaps, it was a word-play created by the Edo scholars themselves. For our purposes, however, it is important to note that Edo-period scholars considered the diverse methods and material means to measure time to be a norm. They did not question the plurality of practical and material conventions of time, and even though they agreed that on the basic level all timepieces were similar, they nevertheless had different characters.

The Adjustment of the Clock

It was this array of time-keeping methods that greeted the mechanical clock upon its arrival to Japan. All these timepieces, the cultural assumptions they reflected, and the modes with which they were handled, shaped the ground on which practices involving mechanical clocks took root. And by doing so, these conventional approaches channeled the way Japanese mechanical clocks evolved.

What motivated clockmakers who decided to change the existing design and structure? And what do these modifications tell us about Edo-period perceptions of time? It is, of course, impossible to answer these questions without taking into consideration the historical reality in

[178] Hirai mentions texts like *Zhou bi suan jing* 周髀算経 (*The Arithmetical Classic of the Gnomon and the Circular Paths of Heaven*), *Zhouli* 周礼 (*The Rites of Zhou*), *Huainan zi* 淮南子(*Masters of Huinan*), in *Tokei no hanashi*, p. 21

which timepieces were used; nor is it easy to find written evidence that will support any kind of answer to these questions, since people tend not to reflect on their daily habits. Yet we do possess historical evidence that can shed light on at least some of these questions — the timepieces themselves, the structure and appearance of which can provide insight into preferences of the people who used them.[179] It is true that artifacts do, in fact, tend to preserve long-lasting conventions that are not necessarily representative of contemporary practices and perceptions; yet, I believe that by focusing specifically on the moments of change and conscious alteration of artifacts it is possible to capture, at least to a certain degree, the motives and mode of reasoning of people who made these modifications.

Slowing Down Time

The most immediate answer to the question why were the Western clocks modified after their arrival to Japan is that they had an obvious disadvantage — "they did not distinguish between long and short hours."[180] Namely, they were simply measuring the wrong kind of time, and only during the time of the equinoxes would be at least somehow comparable. Most of the year, however, the time that they indicated had absolutely no meaning for Edo period temporal system.

Consequently, if Western clocks to be used in Japan, they had to be adjusted to be able to measure hours of changing length. The adaptation of Western mechanical timepieces to variable hours can be seen already in the earliest types of Japanese clock, the hanging clock,[181] and the

[179] Here I am drawing on Lorraine Daston's notion that artifacts are the "crystallized experience" of their creators. See especially: Lorraine Daston, "On Scientific Observation," *Isis* 99, 1 (2008), p. 103; See also Michael Mahoney "Reading a Machine" (http://www.princeton.edu/~hos/h398/readmach/modelt.html); Davis Baird, *Thing Knowledge: A Philosophy of Scientific Instruments*, (Berkeley: University of California Press, 2004).

[180] Nishikawa Joken 西川如見, *Ryōgi shūsetsu* 両儀集説 (*Collected Explanations of Both Models*). Cited in *Tokei no hanashi*, p. 129.

[181] *kake-dokei* 掛時計.

"tower" clock,[182] so named because of the tower-like shape of a pedestal, on which it was placed.[183] This latter type came to be seen as the archetype of all the Japanese clocks in general, and it is this type that usually appears in Edo-period illustrations.

The mechanism of these clocks was practically identical to that of Western devices of the sixteenth century, with the only alteration being made to the locking plate of the alarm (a "snow-wheel"[184]), which was modified to allow the clock to strike the number of times according to the Edo-period hour count, which consisted of double nine-to-four countdown series. These kinds of clocks were driven by the power of falling weights, the (relatively) steady speed of which was controlled by a verge-and-foliot escapement. The verge was a vertical rod, the upper part of which was connected to the crown wheel (a "Sumo-referee wheel"[185]), a wheel that interchangeably held and released the falling weights to prevent them from dropping too quickly. The foliot was a balance attached to the crown wheel and was usually situated at the top of the clock. Two little weights hung from its two sides, fitting into one of the notches that were engraved on it. The position of the little balance weights on the foliot determined the speed with which the verge turned and thus the rate at which it released the large, falling weights. Moving the balance weights to the outer edge of the foliot slowed the rotation of the verge and thus the entire clock; moving them closer to the center caused it to speed up. This device was used in Europe to readjust clocks to the correct speed, since even though ideally the crown wheel was

[182] *yagura* or *rō-dokei* 櫓時計.
[183] The first Western authors to conduct research of these clocks N. H. Mody and Drummond Robertson refer to the latter as a "Lantern Clock" since it was modeled on Dutch *Lantern clocks*. (N.H.N. Mody *Japanese clocks* (Rutland, VT: C. E. Tuttle Co., 1967); Robertson, J. Drummond, *The evolution of clockwork; with a special section on The clocks of Japan, fully illustrated from the author's collection; together with a comprehensive bibliography of horology covering over six hundred authors* (London: Cassell & company ltd., 1931). Nevertheless, I prefer to refer to the types of clocks according to the Edo period Japanese names, as seen in the eighteenth century clock manual *Illustrated Manual of Curious Machines* (Hosokawa Hanzō (Yorinao) 細川半蔵(頼直), *Karakuri zui* 機巧図彙, 1796 in Aoki Kunio et al ed., *Edo kagaku koten sōsho*, vol. 32. (Tokyo: Kowa Shuppan, 1976))
[184] *Yukiwa* 雪輪.
[185] *Gyōjiwa* 行司輪.

supposed to ensure a steady speed, the pressure of the falling weights prevented it from swinging freely, consequently forcing it and the clock to accelerate.

Japanese clock- masters took this device as it was, and used it to adjust the speed of the clock in order to measure variable hours. For the long daytime hours of summer, the weights on the foliot would be moved outwards, and as the daytime shortened, they would be moved closer to the center. Thus from the default position in the center of the foliot, at the beginning of each of twenty-four mini-seasons,[186] the weights would be transferred one notch outwards during the daytime, and one notch inwards during nighttime. [187] This adjustment of mechanical clocks to the variable hours' system is often portrayed as Japanese technical ingenuity,[188] and it certainly required a clear understanding of the mechanism, as well as a certain degree of open-mindedness. Yet, it cannot be regarded as something that European clock-makers had failed to think of. Clearly, the Japanese adjustment of mechanical clocks to measure variable hours points to the fact that there is nothing restrictive in the technology of mechanical clocks, and it is obviously culturally driven choices that have brought about the use of this technology to measure either variable or non-variable hours. The technological potential was always there; it was only the matter of realizing this specific possibility and taking advantage of it. Consequently, instead of pre-determined handling of mechanical technology, we witness a relative freedom of its interpretation on the part of Japanese clock-makers, who were not bound by European assumptions concerning what various parts of the clock were "supposed" or "not supposed" to do.

[186] *sekki* 節気.
[187] In the late eighteenth century Kaga province official, Endō Takanori, came up with a different system in which there was no change, or almost no change in the position of the weights around the solstices. Endō Takanori 遠藤高璟, *Tokei yōhō ki* 時規用法記 (Manual for using the clock), 寛政六 (1794), Tohoku University Archive.
[188] Tsunoyama Sakae, *Tokei no shakai-shi*, p. 50; David Landes, *Revolution in Time*, p. 77.

Perhaps it is not technology itself, but the tacit cultural assumptions that channels the interpretation in a certain direction and structuring its course.

Besides the issue of mechanical structure, though, we also need to consider the question of practicality. Namely, what kind of actions were involved in handling such a clock and what potential problems could arise during these actions? Since all the earlier clocks had only one foliot, but different speeds required of day-hours and night-hours, this meant that the clock needed to be adjusted twice a day— at dawn and at dusk. In addition, controlling the length of the hours by moving the weights on the foliot completely disabled the original function of the device— making sure that the clock did not change its speed *without his owner's intention*. And since the inevitable speeding up of the mechanism happened due to the tendency of the falling weights to accelerate, Japanese clocks had to be wound twice a day. This was not necessarily much more often than a European clock-owner would have had to handle his, since weight-driven European clocks had to be wound once every couple of days. And it was also only twice the number of times non-mechanical timepieces, such as incense clocks, had to be handled. So, if we were to conclude something about seventeenth century Japanese time perception, we could at least say that for them spending some time twice a day on adjusting a timepiece was not perceived as a terrible waste of time.

Adjusting the foliot weights and winding up the whole mechanism were not the only troubles with this kind of device. The structure of the simple verge-and-foliot escapement was such that the friction between various gears was relatively high, causing rapid wearing out of the parts. Moreover, seventeenth-century Japanese clock mechanisms were made entirely of iron, and even when brass became popular in the eighteenth century, clock mechanisms still contained

iron parts.[189] This meant that clocks required periodic maintenance, which included not only minor repairs to a slightly damaged mechanism, but also cleaning, removal of rust, and manual adjustment of the mechanism. A receipt sent to a shogunal family from the clock maker suggests that clocks, some of which were not even broken, were actually taken apart, and after all the parts were cleaned and polished, and the gears repaired, they were assembled anew and adjusted. The receipt does not mention the price paid for this service, only the number of days the clock master expected to spend on each of the eight clocks sent to him, the shortest being nine days, and the longest twenty. It is quite probable that this specific task was not representative of most clock maintenance in that period, since the time spent on each clock was probably determined according to the size and the initial cost of the clock (and most likely according to the status of the patron as well.)[190] Nevertheless, it would be safe to assume that periodic maintenance of even simpler clocks was not at all cheap.

Rearranging the Hours

The introduction of spring-driven clocks to Japan in the beginning of the eighteenth century might seem to have offered a much better technology of an anchor escapement. These clocks were certainly much more precise and more easily handled. And they certainly should have obviated the need for the old and unreliable tower clocks, which demanded constant adjustments and costly care. Yet this was not the case, and weight-driven tower clocks continued to proliferate until the very end of the Edo period. The spring-driven clocks had, of course, some advantages over the hanging clocks and the tower clocks, yet these were mostly related to the mere fact that they were new, and as we shall see later, had an advantageous design. However,

[189] N.H. Mody, *Japanese Clocks*, p. 40
[190] Hirai Sumio, *Tokei no hanashi*, p. 152

what is seen as "better" technology from the modern-day perspective was not necessarily perceived as a top feature in the hierarchy of Edo-period needs.

The square clocks, which did not have weights and did not have to be placed on a pedestal, were known in Japan as "pillow clocks," [191] since the square box that encompassed the device resembled the square stand that was used in Japan to support the neck during sleep. Driven by a spring, these clocks lacked the verge-and-foliot structure that enabled the adjustment of weight-driven clocks to the system of variable hours.[192] Nevertheless, there was a solution for these clocks as well. The minute hand was removed and the digits of the dial, now functioning exclusively as "hour-digits," were placed on a pivot that enabled the physical shift of the position of the hours and determination of their length without changing the speed of the mechanism.[193] This type of a dial is referred to as a "divided (shogi) pieces dial" — *warigoma*. [194]

The same alteration was made to the imported pocket watches, the quantity of which grew steadily from their initial arrival to Japan in the mid-seventeenth century to the very end of the Edo period. [195] It is not clear how small the seventeenth century watches were, though their nicknames, such as "steamed-bun clock."[196] suggest that they were of relatively small size. Later these clocks became know as *netsuke* clocks, because the minuscule parts of their mechanisms resembled the exquisite art of miniature *netsuke* statuettes. Besides changing the dial in order to enable the measurement of Edo period variable hours, these clocks were often incorporated into

[191] *makura-dokei* 枕時計. Mody and Robertson refer to those as "bracket clocks".
[192] There are, nevertheless examples of earlier square shaped clocks, which although also referred to as *pillow* clocks, still used verge escapement, and adjusted the length of hours according with the weights on the foliot.
[193] Landes refers to this as an "ingenious solution." *Revolution in Time*, p. 77
[194] 割駒.
[195] Hirai Sumio cites *Tokugawa Jikki* 徳川実記 (Records of Tokugawa family), where it mentioned that the third shogun Iemitsu (ruled from 1623 to 1651) owned many of those. Hirai Sumio, *Tokei no Hanashi*, p. 124.
[196] *Manjū dokei* 饅頭時計.

portable medicine boxes,[197] which, due to the lack of proper "pockets" in the clothing of that time, were often carried on one's belt. The portability feature was certainly welcomed due to its convenience for telling time when away from home, yet it was also convenient for increasing the amount of opportunities to casually, and seemingly unintentionally, show this sophisticated device to others.

Unlike hanging and tower clocks, which were produced from scratch in Japan already in the beginning of the seventeenth century, most of the "pillow" and *netsuke* clocks seem to have used Western mechanisms.[198] In fact, some of the eighteenth century sources directly say that pillow clocks and *netsuke* clocks were all originally imported,[199] and even in the beginning of the nineteenth century, we see statements saying that "in many cases" the mechanism of the *netsuke* clocks was foreign and only the dial was changed "here," in Japan.[200] Namely, in most cases, the Western mechanism was taken as it was, and incorporated into a new case, ornamented with a Japanese-style design and equipped with a movable-digits dial and a single index hand.

This shifting of the hours might seem odd or even unthinkable for us today, since we are so used to associating hours with their position on the dial. In fact, we don't need the digits at all - we can determine the hour by simply looking at the position of the index hands, even when the dial itself is absolutely blank. Why was this relation between the hour and its physical location on a dial so easily dismissed in Edo-period Japan? To be sure, the hours *were* associated with geographical directions and the Japanese compass dial did look exactly like an ideal clock dial

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[197] *Inrō* 印籠.
[198] Kondō Katsuno shows evidence that some *pillow* clocks were produced by Japanese clock-masters as well. Kondō Katsuno 近藤勝之, *Saishoki makuradokei ni tsuite* 最初器枕時計に付いて ("About early period *pillow* clocks") in *Wadokei Kenyū* (Journal of the Wadokei-Gakkai), Otsu: Wadokei Gakkai, 41, January 2007, p. 1.
[199] Nishikawa Joken 西川如見, *Nagasaki Yawasō* 長崎夜話草 (Night-time stories of Nagasaki), reprinted in *Nagasaki Sōsho* 長崎叢書 (Nagasaki Series) (Nagasaki: Nagasaki Shiyakusho, 1926), p. 80.
[200] Kyūshidō Shūjin 求巳堂主人, *Shōchū jishingijimō* 掌中時辰儀示蒙 (Pointing out Mistakes About the Hand Watch), 万延元 (1860) copy - originally published in 文政元 (1823), Tokyo University Archive.

with invariable hours would look. Even in speech, if one wanted to say that something is at "north-west", one would say it is at the *inu-i* direction, which literally means the direction of "Dog-Wild boar" hours. Yet strangely enough this association does not seem to have been too much obliging when it came to timepieces. It is impossible to determine what the reason was for this *lack* of care, and there is certainly not enough historical evidence to support any claim concerning it. But in attempt to understand this *flexibility* of perception of the position of the hours it is worth noting other existing time-keeping practices of the period. In fact, none of the non-mechanical timepieces used in Japan, both before and after the arrival of mechanical clocks, obeyed this association. The nails indicating the hours on the incense burner were *affixed* into a shape that had nothing to do with directions; clepsydra indicated the hour by the level of the water; star constellations changed their position in the skies; and the shadow on the gnomon was measured on a one-dimensional scale. The various indicators of the hours could be therefore arranged in many possible ways, and their location was not perceived to be predetermined. There were no assumptions concerning the "proper" place, and hence placement, of the hour digits. Consequently, accustomed to these practices, the clock makers were open to the possibility of seeing the place of hour-digits on the dial as detached from a fixed place.

Picturing Time

Changing the clock did not only mean its adaptation to the system of variable hours – the whole appearance of the dial was altered in order to fit existing notions of how time was supposed to look. The visual appearance of "timepieces" can hardly be described as a "problem" one had to solve, since the various appearances of timepieces did not necessarily correlate to

specific practical needs.[201] Nevertheless, the visual convention, the cultural assumptions embedded in them, and the modes of looking at the information contained on the clock-dial, played an important role in shaping Japanese clocks. One obvious alteration of this kind was changing the Roman numerals to digits featuring the twelve animal signs and the double series of nine-to-four digits.[202] Along with adapting the clock mechanism to measure variable hours, this kind of alteration to the dial was seen as the most basic and essential measure to enable the use of mechanical clocks in Japan. Indeed, except for the first clocks brought to Japan by the Jesuits and the clocks imported from the West on the eve of Meiji period, there were virtually no clocks with Western style digits.

On top of the change of digits, there were some additional alterations made to the round dial. One immediately apparent feature was that there was no standard way to arrange either the digits or their movement. On some of the clocks, the noon hour was placed at the top of the dial, on others, it was at the bottom; sometimes it was the index hand that rotated, and sometimes the index was stable and the dial itself rotated; sometimes the rotation was clockwise and sometimes counter-clockwise. As was the case with the multiple non-mechanical timepieces, there was no one standard way to look at a clock — one had to learn the device first, and then match the digit with the single index hand that pointed to it.

One of these alignments is relatively easy to explain in terms of the correlation between the hours and geographical directions. The Rat, which is the midnight hour, also associated with the winter solstice, represents the north; the Horse, being the animal of noon and the summer

[201] Technological developments as a problem-solving process is famously described in the investigation of earlier bicycle models by Trevor Pinch and Wiebe Bijker in Trevor J. Pinch and Wiebe E. Bijker, "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other," in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, eds., Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch (Cambridge, MA: MIT Press, 1987), pp. 17-50.

[202] For the explanation of Edo period hour counting see chapter one.

solstice, represents the south. Unlike the present day depiction of directions,[203] Edo period Japanese followed ancient Chinese tradition and represented the north as being at the bottom, perhaps referring to the North Pole as being beneath the Northern Star. Consequently the midnight *Rat* digit, too, was often placed at the bottom of the dial. Yet, as was already mentioned, this association was not obligatory at all, perhaps due to the fact that even the maps of the Edo period were not necessarily aligned according to the top-to-bottom arrangement, regardless of whether the north was supposed to be at the top or at the bottom.[204]

This continuum of practices related to timekeeping and to the representation of time itself is clearly seen in the case of another type of Japanese clock – the *shaku* clock. A *shaku* was a unit of length measuring about one foot, and although the clocks were not necessarily one foot long, they did resemble the measuring rod that was used in order to measure the length of one foot. Since this type of clock was a local Japanese invention, its design deserves special attention. First clocks of this type were weight driven and had a relatively simple mechanism – the falling weights simply pulled the index hand downwards, and all that was needed in order to make this plank-and-weights combination a timepiece was an escapement mechanism that would cause the weights to fall at a (relatively) steady rate. And yes, it had to be wound every single day, since the mechanism could only go down, with no automatic feature to bring it back to the top. This was probably the reason for arranging the digits from the hour of the dawn at the top to the next hour of the dawn at the bottom, so that the owner wouldn't have to get up in the middle of the night to wind his clock.

For dealing with the changing length of hours there were two solutions. One solution, similar to that of the pillow clock and the *netsuke* clock, was the use of movable digits, which

[203] In fact, even today public maps are not necessarily aligned with the north at the top.
[204] Many maps were not viewed from the birds-eye view but rather from the perspective of the viewer.

were manually shifted to the right position. Another solution was simply to have a set of plates that were replaced every "mini season" of Japanese calendar— *sekki*,[205] which lasted approximately fifteen days. Both of these solutions were also implemented in later models that used a simple spring mechanism rather than relying on falling weights.

One could claim that this peculiar shape of the dial was determined by the need to accommodate a simpler mechanism; yet the fact that this shape was preserved in spring-driven devices, and the fact that there were even horizontal *shaku* clocks, tells us that there must be some additional cause for this choice. But why would it even be possible to think that one could arrange the hours on a linear scale instead of the round continuum? The answer is that not only *was* it possible, but it was actually *done* quite often prior to, and during the Edo period, when using a gnomon. In fact, the shape of *shaku* clock is almost an exact replica of a gnomon, turned vertically; and the movement of the hours up and down the scale during different times of the year constitutes the very feature that makes it a time telling device.

The attempt of Edo-period clock-makers to recreate a familiar interface of a time-keeping device in a mechanical clock is further seen in a graph-like version of the *shaku* clock. In order to read time off this type of the clock, one had to match the pointing index hand to the column of the clock corresponding to the relevant time of the year. As confusing and inconvenient as this arrangement might seem to a modern-day viewer, the practice of checking the time by looking at a graph was by no means new to Edo-period consumers. Paper sundials were made of several slips of paper of various length, that were lifted at different times of the year, while calendars and manuals dealing with issues of time often visually represented the change in the length of hours as a series of columns that created one united graph, identical to that seen on the graph-like

[205] 節気.

shaku clock. Similarly, rare round-graph *shaku* clocks,[206] too, were no exception, and they, too, were directly modeled on visual representation of the yearly distribution of hours as a round graph, as seen for example in *Illustration of Long and Short Days and Nights*. [207]

Perfecting Technology

Looking at the evolution of Japanese clocks sketched above, a positivist reader might conclude that besides constant inflow of the newest Western clocks, Japanese technology developed backwards. Indeed, instead of becoming more complex, the structure of *shaku* clocks was much simpler than their predecessors; and even if the clocks did not necessarily become *less* precise, unless they used imported mechanisms, they did not show any tendency towards increased precision. On top of that, it seems that all that Japanese clock makers and consumers wanted, was for their clocks to look like non-mechanical timepieces.

Yet these tendencies do not necessarily point to a lack of competence, but rather to the fact that there were numerous goals guiding artisans in their development of new models; and that these goals reflected a certain kind of hierarchy of preferences. To clarify this point, let us look at the opposite cases – cases of fine technology that was not seen as overwhelmingly advantageous and in some cases simply failed to win the hearts of consumers.

One example that does not align with the teleology of improvement is the invention of a double foliot verge escapement. Previously, it was mentioned that clocks driven by a verge escapement mechanism had to be adjusted twice a day in order to reflect the variable length of

[206] There are only clocks of this type that survived to the present. Kondō Katsuno 近藤勝之, *Furiko en gurafu shiki mojiban kakedokei* 振り子円グラフ式文字版掛時計 ("Hanging clock with a round graph-like dial"), in *Wadokei* (Journal of the Wadokei-Gakkai), 38, December 2007, p. 4.
[207] Endō Ōsekishi 遠藤黄赤子, *Chūya chōtan no zu* 昼夜長短之図 (Illustration of Long and Short Days and Nights), 宝永六 (1709), Tohoku University Kanō archive.

the night and day hours. Nevertheless, sometime at the end of the seventeenth century we witness the emergence of a clock with two foliots – one for the night, and another for the day hours – which switched automatically at appropriate times.[208] This technological novelty seems to enormously simplify the daily task of handling the clock, significantly reducing the number of necessary adjustments. So if there were a clock that could run fifteen days consecutively without intervention, it could be handled only once in every *sekki*. However, certainly in the seventeenth century there were no such clocks available, and the weights had to be wound more frequently than the adjustment to the foliot. In spite of that, even the reduction in the number of necessary adjustments from twice a day to once in several days seems an incredible improvement. Yet these double-foliot clocks failed to sweep the market for at least some hundred years. It is only in the nineteenth century that we see more clocks of this type, and even then, they do not supplant the single-foliot ones completely.

Another case of unappreciated automation is the round-graph *shaku* clock. The inscription on one of these clocks specifically says that there is no need to adjust the clock to seasons manually,[209] since the device does it on its own. And indeed these pendulum driven clocks were fully automated, except, of course, for the occasional need to be wound. It is hard to establish the exact reason why this design failed to catch on, but obviously the apparent advantage of automation was not seen as good enough reason to ignore its other possible shortcomings.

The final example is considered to be the pinnacle of Edo period clock making, or even Edo period mechanics in general. The device in question is the *Myriad Years Clock*,[210] created in

[208] Tsunoyama Sakae, *Tokei no shakai-shi*, p. 52.
[209] Transcribed in Katsuno Kondo, *Furiko en gurafu shiki mojiban kakedokei*, p. 5
[210] *Man-nen dokei* 萬年時計.

1851 by a mechanical genius Tanaka Hisashige.[211] Also known by his nickname Karakuri (automata) Giemon,[212] the master was known for his invention of both intricate automata, such as the arrow-shooting boy, and for the practical invention of an "inexhaustible" oil lamp, water pumps, looms, mechanical fans, and later improvements to the novel telegraph system.[213] As many other of his inventions, the clock promised a complete automation — it would go for "myriad years", or at least for one whole year without the necessity of winding it up.[214] It also promised multi-functionality as it had a celestial globe on top of it and six interconnected dials. The celestial globe showed a map of Japan with red and silver balls rotating around it, imitating the actual movement of the sun and the moon in the skies above Japan. The map is centered on the 136° E longitude and 35° latitude, while the red ball representing the sun reached the altitude of 55° at the time of the equinoxes, 78.5° on summer solstices and 32.5° on winter solstices — parameters that correspond to the geographical location of Kyoto, and which was used as a basis for creation of calendars for all of Japan. [215] The first of the six dials showed the hours of the day according to the Japanese system of variable hours, automatically changing the length of the hours from season to season; the second dial was a manually adjusted and showed the solar seasons; the third showed the days of the week; the fourth showed the date according the

[211] 田中久重 (1799-1881).
[212]からくり儀右衛門.
[213] After the Meiji Restoration, Tanaka Hisashige moved to Tokyo and opened an electric workshop that eventually evolved in to the present day Toshiba Corporation. Teiichi Asahina and Sachiko Oda, ""Myriad-Year Clock" Made by G.H. Tanaka 100 Years Ago in Japan," in *Bulletin of National Science Museum*, Vol. 1, No. 2 (September 1954), p. 2.
[214] Although two separate investigations of the device in 1950s and in early 2000s came to the conclusion that it would have to be wound every 225 days or so. Teiichi Asahina and Sachiko Oda, ""Myriad-Year Clock" Made by G.H. Tanaka 100 Years Ago in Japan," p. 3; Kazuyoshi Suzuki et. al. *Mechanism of "Man-non dokei," a Historic Perpetual Chronometer. Part 2:Power Supply*, 12th IFToMM World Congress, Besançon (France), June 18-21, 2007, p. 3.
[215] Kazuyoshi Suzuki et. al., *Mechanism of "Man-non dokei," a Historic Perpetual Chronometer. Part 1: Celestial Globe and Japanese Traditional Clock*, 12th IFToMM World Congress, Besançon (France), June 18-21, 2007, pp. 2-3; Takehiko Hashimoto, "Hisashige Tanaka and His Myriad Year Clock" in *Historical Essays on Japanese Technology* (Tokyo: Collection UTCP, 2009), pp. 31-45.

sexagenarian cycle that combined the ten celestial *stems* with the twelve terrestrial *branches*; the fifth showed the date according to the lunar calendar; and the sixth showed the hours according to the Western temporal system. The interconnected parts included specially designed gears, such as an "insect-shaped" gear that allowed gradual approaching and retreat of the movable digits, *warigoma*. The gears and the springs were all handmade, yet executed with exquisite precision, unprecedented in Japan.

It seems that the clock addressed any possible timekeeping need a mid-nineteenth century user could have encountered, and yet, to Tanaka Hisashige's great disappointment, this pinnacle of mechanical ingenuity proved to be a complete failure in economic terms. Although Tanaka Hisashige made a special effort to advertise the clock through copperplate prints, the enormous cost of it deterred even the richest or the most technology-crazy potential buyers. In order to make up for the cost of the production of the clock, Tanaka Hisashige was forced to travel with it around the country, charging money for the viewing of this technological wonder.

The clock indeed offered many solutions to possible timekeeping problems that could arise in the mid nineteenth century, but clock users did not necessarily thought that these problems were ought to be solved. Even if there were professionals or amateurs who needed to use all the available modes of time-measuring simultaneously, they preferred to have a variety of timepieces, each one for a different type of time. Not because they couldn't see the possibility of combining them both, but just because this was the way they were used to measure all the various times in their lives.

Conclusion

With the expulsion of Europeans from Japan in the beginning of the seventeenth century, mechanical clocks that remained on Japanese soil came to be separated from their social background and cultural associations. Only several decades after their initial introduction to Japan, the clocks were not yet seen as a part of larger set of European practices and were not yet bound by a set of practical and visual associations. In this situation, their apparent failure to revolutionize Japanese society and the radical transformations they themselves went through serves as a powerful counterpoint against blatant technological determinism. No, technology itself does not necessarily have a predetermined trajectory of development and it does not necessarily produce a certain kind of change in social structures.

Instead, unrestricted by assumptions about "proper" use of clock making technologies, and not bound by conventions of looking at a clock and reading the hours, Japanese clockmakers and consumers were free to interpret this technology according to their own ideas and needs. But these needs were not only shaped by specific social situations in which time-keeping was needed, they were also shaped by existing practices that involved non-mechanical timekeepers — practices that determined the archetypal idea of 'what is time,' 'how do we handle it,' and 'what does time look like.' When mechanical timekeeping technology arrived to Japan, Japanese users were not aware of the European assumptions and associations embedded in them. It was only after they tied the physical properties of Western clocks to the existing timekeeping practices and associations that clocks started to make sense in Japan. But the process of incorporating of mechanical clocks into the Japanese temporal landscape demanded substantial modification in almost every aspect of the mechanical clock — in the mechanism itself, in the way hours were counted, referred to, and even looked at.

So what do we learn from the way Japanese clockmakers interpreted the clock mechanism? One claim that simply does not apply to the Japanese clocks is that technology always develops from rudimentary to complex and refined. [216] Let us set aside, for a moment, the questions of what do we mean by "complex" or "refined," or whether these two categories are necessarily directly related. Simply looking at the trajectory of development of everyday-use Japanese clocks, we can firmly claim that in spite of the periodic injection of novel Western technologies into the Japanese market, clock technology sometimes took the opposite route, and became simpler. And even when we see tendencies towards more complex structures, those seem to have failed to supplant the simpler mechanical devices; they certainly were not powerful enough to obviate the demand for non-mechanical timepieces. The complexity of the device, its increasing precision, automated and multiple functions — all of these cannot be seen as overarching goals that dominated the motives of Japanese clock-makers. While there are examples that show concern with these goals, those are quite outstanding and only highlight the general trend in the popular clocks.

Nor is it entirely possible to analyze the evolution of the clocks as a process of problem solving. It is true that adjustments of European clocks to the local hour digits and the variable hours could fall under the category of "problem solving," Yet we need to account for the fact that these "problems" were far from being the only ones Edo period consumers encountered. Even after the adjustment, the clocks seemed to present more problems than solutions: they were cumbersome and costly, constantly struggling to produce a required measurement, and there was nothing that seventeenth and eighteenth century clocks did that couldn't have been achieved by incense clocks and sundials. Therefore, if we approach technological development as a perpetual

[216] Landes, *Revolutions in Time*, p. 55

process of solving of ever-emerging problems, we need to first ask ourselves, what were the problems that were considered to be worth solving and which were the problems that people decided not to solve and to endure the inconvenience.

The case study of Japanese clocks also points to another problem with the "problem solving" approach. The idea that technology develops as a series of steps in which newly arising problems are constantly solved (or at least attempted to), is based on a synchronic perception of a society — at a specific moment, with all its social structures, practical necessities, power struggles etc. Yet this sociological approach does not account for the long history that preceded this moment — history that not only shaped the social makeup, but also influenced the very way ideas, objects and practices were conceptualized. Japanese clocks, on the other hand, reveal the importance of technological conventions — both in their freedom from European conventions and in their adherence to conventional timekeeping practices with non-mechanical timekeepers.

The history of Japanese clocks shows us that a part of clockmakers' motivations to change the shape of the clock derived from their ideas of how information about time should be visualized and perceived. Japanese clocks show that there are multiple ways to visualize the movement of time, but they also suggest that the ways to visualize time are deeply embedded in the material means by which people are *accustomed* to measure time. Consequently, rather than following new technology and its appearance, Edo period clockmakers created designs that exhibited familiar features of non-mechanical timepieces or visual representations of time, molding clock-making technology into familiar practices and recognizable shapes.

But there is one more aspect that we can learn from the analysis of Edo-period mechanical clocks. In addition to pointing out Edo period notions of what time should look like, these clocks also provide us with a glimpse into the broader perception of time in that period.

Looking at the relative freedom with which clockmakers modified the dials, making it rotate or be stable, making the rotation clockwise or counterclockwise, making the dial rotate or making it linear and non-continuous, or even changing the number of digits on the dial to thirteen, one cannot avoid the conclusion that there was simply no one standard clockmakers were compelled to adhere to. It seems that the timepieces of Edo period were not just one category, superficially decorated or fit into various sizes. Rather, it was a fluid and constantly evolving material, which reflected the idea that "time" was not restricted to one shape, and it was not embedded in a particular type of a timekeeper. There were many concurrently existing kinds of time.

Chapter 3: Timekeepers and The Creation of Time

Introduction

In the previous chapter we saw how prior habits of dealing with time-keeping technology, existing time-related tacit assumptions, and visual associations shaped the way novel mechanical time-keeping technology was interpreted and modified in Japan. European clocks were integrated into, and evolved within the sphere of practices and assumptions associated with time in Edo period. The question, however, is whether the range of influencing practices and assumptions was limited to the realm of time-keeping alone. What were the other considerations that affected clock-users' approach to timekeeping and timepieces? And what was hiding behind the apparently straightforward and unambiguous acts of measuring time?

In order to answer these questions, let us examine the timepieces and the changing timekeeping practices of one particular field — astronomy. At a very superficial glance, the timekeeping practices of astronomy seem to be quite homogenous — all astronomers were driven by the same goal of improving the calendar, refining their calculations and correcting the mistakes of their predecessors. It seems only natural to assume that the difference between the timekeeping practices of various astronomers of the Edo period was only a matter of increasing quality of available timepieces. Yet this was hardly the case in the history of Edo astronomy. A closer examination of various timepieces used by leading Japanese astronomers, and the timekeeping practices associated with them, shows that timekeeping was defined by specific astronomical concerns and calculation methods employed by these various individuals. All astronomers might have been engaged in timekeeping, yet the "time" they were measuring was different.

It was therefore not only the practical habits, assumptions and associations directly linked to timekeeping that created the specific shape of time and timepieces; rather, it was also the choice of astronomers to incorporate practices they deemed relevant into the process of astronomical timekeeping that shaped their time-measurement, timepieces, and the concept of time they held.

Astronomical Time and Timepieces

Timepieces are certainly not the first instrument that comes to mind when we think of astronomers' craft; rather, in popular imagination they are often overshadowed by impressive armillary spheres and powerful telescopes. Yet armillary spheres were extremely expensive and immobile, forcing many astronomers to manage without them, while telescopes were relative newcomers to this ancient profession. Timepieces, on the other hand, were always essential for astronomical practice, and without them astronomers could not have accomplished their main task — making a good calendar. This might be the reason behind the fact that out of forty devices discussed in length in *Illustrations of Various Measurement Devices*, twenty-three were related to time measurement.[217] Fourteen of them were timepieces in a strict sense — sundials, mechanical clocks, clepsydras and an hourglass; others were auxiliary devices designed to refine observation, such as the "shadow-pointer" designed to narrow the measured shadow cast by the gnomon to refine the observation. And even unrelated devices such as compasses are discussed in the context of positioning a sundial. The only devices that were not necessarily related to some

[217] *Sokuryō sho ki no zu* (Description of Various Mesurement Devices), National Astronomical Observatory of Japan (NAOJ) archive. The NAOJ database lists this work as written by "anonymous", but Watanabe Toshio identifies the author as Kaga domain astronomer Nishimura Tōsato 西村遠里 (1718-1787). See Watanabe Toshio 渡辺敏夫, *Kinsei Nihon tenmongakushi* 近世日本天文学史 (*History of Early Modern Japanese Astronomy*) (Tokyo: Koseisha Koseikaku, 1986-7), vol. 2, *Kansatsu gijutsushi* 観察技術 (Observation Techniques) (Tokyo: Kōseisha Kōseikaku, 1987), p. 556.

kind of time measurement were telescopes, quadrants and sketching tools such as rulers and brushes.

Why was time measurement so central to astronomical practice? One of the essential elements that stood at the basis of every calendar was correct estimation of the length of a tropical year, which was often done by measuring the exact time of the solstices or the equinoxes. One would think, though, that even a gross miscalculation of the tropical year by a day or two would not be apparent to a lay calendar user; however, there were certain times when even a slight mistake became clearly visible— the time of eclipses. Consequently, astronomers concentrated their efforts on correctly predicting and measuring the timing of the eclipses, as a means to test the quality of their calendrical systems.[218]

Making a good calendar, though, required much more than observations and recording of time. Most of astronomers' work consisted of making and refining mathematical calculations, and observations only supplied a certain amount of data to be used in the algorithm. In this case, using hours of variable length and animal signs would probably add more complicating dimensions to the already complicated calculation. And indeed, since the introduction of the Chinese temporal system to Japan there was not one, but two types of time that existed simultaneously – the civil and the astronomical. Most of the non-professionals in the Edo period were probably not aware of the existence of astronomical time; and those who were aware of its existence could not necessarily make sense of it, as it was quite different from that of the civil world. No longer variable length of hours and no longer the peculiar count of double nine-to-

[218] Ecplipses are often associated with astrological practices, and one might assume that astronomers were concerned with their status as bad omens. Astronomers however, long perceived eclipses to be regular phenomena, and their mere predictability contradicted any association with divine. None of the astronomical treatises, personal writings or letters surveyed in this study shows perception of eclipses as omens. Rather, they were taken to be opportunity to test the quality of existing calculation and learn more about celestial bodies and their movement.

four series: the astronomical day of Edo period was divided into a hundred equal units, called *koku*[219] which could be further divided into smaller and smaller units.[220] These hundred *koku* were mapped onto twelve hours of invariable length, so that every hour contained exactly eight and one-third of a *koku*. The hours, nevertheless, were still referred to by the animal sign count, i.e., "rat", "ox", "tiger" etc, while the numerical count, i.e., 9, 8, 7, 6…, was reserved for the civil hours only.

As we have seen in the previous chapter, Edo period timepieces of the seventeenth and the eighteenth centuries varied greatly because they were bound neither by one specific category of "time" nor by the singular time measuring practice. It is not surprising, therefore, to find out that the evolution of timekeepers in the field of astronomy differed considerably from what was described in the previous chapter concerning everyday-life timekeepers. After all, timekeepers in civil life measured already established time, and their primary function was to *notify* people of the time in different situations; in astronomical practice timekeepers were crucial components of the process the end goal of which was the *establishment* of this very time that would later be measured and announced by the civil clocks. To put it differently, whereas everyday timekeepers were concerned with specific points of time, astronomical timekeepers were responsible for correct prediction of timing over the course of long periods.

Yet this broad definition of astronomical time-keeping conceals great diversity that characterized time-related practices of different astronomers. Let us examine what exactly different astronomers meant to do when they measured "time", and how they employed relevant patterns of practice in their creation of time.

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[219] 刻.

[220] In some instances a division of the day into 96 units was used, though this system was not popular in the Edo period.

Jōkyō Reform and the Universal Hoop of Time

In the course of several hundred years after the initial introduction of Chinese calendrical science to Japan, a number of calendrical reforms took place, finally settling on the solid astronomical algorithm known as the *Seimyō*[221] calendar in the end of the ninth century.[222] Yet, there could not be a perfect calendar, and even the best of them could not survive the trial of time. To borrow Shigeru Nakayama's analogy "if one is having even slight inclination on a totally straight highway, he is going to get off the road, eventually."[223] Consequently, after eight hundred years without any reform,[224] the discrepancy between the calendar and the observable phenomena was as large as two days, and eclipses predicted in the calendar did not occur.[225] The fact that the government allowed this obvious, and constantly growing divergence to take place is not surprising in itself, especially when we compare this case to the European one, where Gregorian reform followed more than sixteen hundred years of no change. After all, as many historians have already noted,[226] the decision to reform the calendar was essentially a political one. This political need emerged in the beginning of the Edo period that was marked by a vast range of reforms of various kinds. It was not long before the reform of the calendar too became an urgent matter.

What was surprising in the first calendrical reform of the Edo period was the person who was ordered to design the new calendar. Rejecting the obvious choice of members of

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[221] 宣明.
[222] 貞観四 (864AD).
[223] Shigeru Nakayama, *Nihon no Tenmongaku* 日本の天文学 (Japanese Astronomy) (Tokyo: Iwanami Shoten, 1972) p. 45.
[224] Prior to the Edo period, the last calendrical reform was carried out in 862 AD. Shigeru Nakayama, *Nihon no Tenmongaku*, p. 44.
[225] Shigeru Nakayama, *A History of Japanese Astronomy* (Cambridge: Harvard University Press, 1969), p. 119.
[226] Nakayama, *Nihon no Tenmongaku*, p. 43.

Tsuchimikado[227] family who held the hereditary post of government astronomers from as early as eleventh century and disregarding other prominent candidates such as the famous mathematician Seki Takakazu,[228] the regent of the fourth shogun, Hoshina Masayuki[229] chose instead a young and virtually anonymous man who was hired to play *go* against members of shogunal family.[230]

Born as the eldest son of shogunal *go* partner,[231] this man would become one of the most important astronomers of the Edo period, widely known under the name Shibukawa Shunkai.[232] Being a *go* player was actually considered to be a very respectful position, since engaging in this strategic game was an obligatory recreational activity of any political figure. Being a *go* player, therefore, required quite sharp analytical skills which Shunkai developed through his studies of Confucianism, cosmology, mathematics and medicine.[233] It was during his studies that Shunkai met a Korean scholar, Yō Razan[234] who introduced him to the thirteenth century Chinese calendar,[235] the title of which was elegantly translated by Nathan Sivin as *Granting the*

[227] 土御門.
[228] 関孝和 (1642-1708).
[229] 保科 正之 (1611–1673).
[230] 囲碁.
[231] Yasui Santetsu 安井算哲 (1590-1652).
[232] 渋川春海 (1639-1715). Also read as *Shibukawa Harumi*.
[233] Shunkai studied Confucianism and *Suika Shintō* 垂加神道 cosmology under the famous philosopher Yamazaki Ansai 山崎 闇斎(1619‐1682). Both the kind of Confucian philosophy and Shintō propagated by Ansai was highly metaphysical, stressing the structural harmony that could and should be found in the apparently diverse universe. This cosmological quest for harmony was probably one of the most prominent intellectual influences on the young go player. Young Shunkai also studied mathematics under Seki Takakazu 関孝和(1642-1708) and medicine under Okanoi Gentei (岡野井玄貞). Hayashi Makoto 林淳, *Igo to tenmon* 囲碁と天文 ("*Go* and Astronomy") in Ōsumi Kazuo 大隅和雄 ed., *Bunkashi no shosō* 文化史の諸相 (Various Aspects of Cultural History) (Tokyo: Yoshikawa Kōbunkan, 2003) pp. 258-287.
[234] 容螺山. According to Shunkai's student, Tani Shinzan 谷秦山 (1663-1718) in *Shunkai Sensei Jikki* 春海先生実記 (Records of Master Shunkai). Cited in Nakayama, *Nihon no Tenmongaku*, p. 48
[235] Hisashi Uehara 上原久 et al ed., *Tenmon rekigaku shoka shokanshū* 天文暦学諸家書簡集 (Collection of Various Astronomers' Correspondence) (Tokyo: Kodansha, 1981), p. 17.

Seasons.[236] What attracted Shunkai and others to this ancient calendar, was not its social significance, which any calendar bore, but rather the elaborate mathematical calculations involved in its compilation. Astronomical practices Shunkai learned from *Granting the Seasons* calendar added to his already outstanding analytical abilities, and when appointed by Hoshina Masayuki to devise a calendrical reform, Shunkai did so by adjusting Chinese calendar to the geographical location of Japan.

The system designed by Shunkai was far from perfect,[237] and Shunkai's miscalculation of 1675[238] eclipse was even more off than the calculation based on the previous, *Seimyō* calendar.[239] This miscalculation resulted in temporary postponement of calendrical reform, but political pressure to carry out *any* kind of reform bore fruit, and in 1685, or Jōkyō 5 according to the Edo period year count, the new calendar, titled accordingly "the *Jōkyō* calendar", was established.

This new Jōkyō calendar, designed by Shibukawa Shunkai, bore several time-related innovations. The first one was the awareness of the time differences between distant geographical regions. Previous calendars designed in Japan in the seventh to ninth century all adopted Chinese systems *as they were*; but Shunkai, although faithfully following *Granting the Seasons* in the use of astronomical notions and mathematical methods, also took into account the

[236] 授時暦 Jap: *Jujireki*; Chi: *Shoushi li*. This title was not just poetic superfluity but rather expressed an underlying ideological stance according to which a benevolent government is responsible to supply the citizens with a proper calendar in order to enable proper agricultural activities. Nathan Sivin, *Granting the Seasons: the Chinese astronomical reform of 1280, with a study of its many dimensions and a translation of its records* (New York: Gardners Books, 2008).

[237] Shunkai relied on the assumption that the daily change before and after the solstice was symmetrical. In fact, it could only be symmetrical when the winter solstice (i.e., the maximum inclination of the southern hemisphere to the sun) coincides with the perihelion (i.e., the earth's nearest point to the sun), which incidentally was the case in the thirteenth century when the author of the *Granting the Seasons*, came up with this calculation. Nevertheless, since the perihelion moves on the orbit, by Shunkai's time the two values no longer coincided – a fact that resulted in serious miscalculations in Shunkai's calendar. Nakayama, *A History of Japanese Astronomy*, p. 124.

[238] 延宝三.

[239] Hayashi, "Igo to tenmon," p. 258.

geographical distance between China and Japan,[240] putting forward two novel notions of "difference in distance"[241] and "difference in observation."[242] He was also the one to write at length about the difference in timing of the seasons between Japan and China, even proposing his own list of the seventy-two mini-seasons that was supposed to reflect better the "Japanese" temporal arrangement of the seasons.

Another important contribution of Shunkai was an introduction of the notion of *byō*[243] to Japanese astronomical discourse. Today this word is used to signify a "second" and in a certain sense, Shunkai's notion is very similar to the Western etymology of this word, as the secondary division of the already tiny, "minute" divisions of daily units. The actual value was, of course, completely different — one *byō* was one-tenth of a *bu*, which was one-tenth of a *koku*, which was one-hundredth of a day. Consequently, Shunkai's one *byō* equals 8.64 seconds in present day terms. No timekeeper at that time could measure such a unit, and this notion was purely theoretical. It was needed to describe the so-called *Law of Vicissitudes*[244] according to which the length of the year was slowly but constantly shrinking. *Granting the Seasons* established that every hundred years, a year gets shorter by 0.0002 of a year. Shunkai subsequently deduced that every year is shorter by 0.000002 of a year, or by 0.07305 of a day.[245] Nevertheless, perhaps due to his cosmological convictions, Shunkai took this value to be too crude and seemingly non-

[240] Here, the difference between Japan and China means the difference between Kyoto and Beijing.
[241] Jap. *Risa* 里差.
[242] I.e. parallax, Jap. *Shisa* 視差.
[243] 秒. Sometimes read as *myō.*
[244] 消長法 Jap: *Shōchōhō*; Chi: *Xiaozhangfa*.
[245] *Shoushi li* and consequently Shunkai, take one year to be 365.25 days.

harmonious, and decided to round it up to the exact measure of one ten-thousandth of a day — a *byō*.[246]

The third time-related innovation of Shunkai was his original timepiece. Although many records[247] indicate that he used an armillary sphere as well as several types of gnomons, which could be perfectly satisfactory for measuring time for astronomical calculations, Shunkai had an additional, special timekeeper, which he named *A Hundred Koku Hoop*.[248] This device, has not survived to the present, and in fact was no longer extant by the second half of the eighteenth century, when Nishimura Tōsato wrote his *Illustrations of Various Measurement Devices* that included a discussion of it. Therefore, both Nishimura Tōsato and a modern reader have no choice but to rely on the only source that describes the device – the records of Shunkai's student Tani Shinzan.[249] In his *Records of the Years 1672-1673*[250] the latter describes the timekeeper as "a ring of one foot and three inches (or, one *shaku* and three *sun*) in diameter, one inch wide and three tenth of an inch (or, three *bu*) thick. Carved on its back are the degrees of heavenly rotation; on its belly are carved the hundred *koku*. The middle is pierced by a wooden rod." This ring was installed in a square horizontal pedestal and aligned to the north. On the northern and southern sides there were handles that enabled it to tilt the ring "according to every country," i.e., according to different geographical location. By observing this ring, 'one can see the sun's

[246] Watanabe Toshio 渡辺敏夫, *Kinsei Nihon tenmongakushi* 近世日本天文学史 (*History of Early Modern Japanese Astronomy*) (Tokyo: Koseisha Koseikaku, 1986-7), vol. 1. *Tsūshi* 通史 (Comprehensive History), pp. 73-74.
[247] Shibukawa Shunkai (Harumi) 渋川春海, *Tenmon keitō* 天文瓊統 (*Astronomical Gem String*), 元禄十一 (1698), reprinted in *Nihon shisō taikei* 日本思想大系 (Compendium of Japanese Thought), vol. 63, *Kinsei kagaku shisō ge* 近世科学思想下 (Second volume of Early Modern Scientific Thought) (Tokyo: Iwanami Shoten, 1971), p. 132; Also, see Nishimura Tōsato in *Illustrations of Various Mesurement Devices*.
[248] *Hyakkoku kan* 百刻環.
[249] 谷秦山.
[250] The title is in fact better translated as *The Records of the Year of Water-Elder Brother, and Year of Water-Younger Brother*, while the context of the record suggests that those were the years of 1672 and 1673. For the sake of convenience, I have rendered the years into units meaningful to all the readers.

rotation each season, as in all four seasons the ring receives the sun. From dawn to sunset, the sun makes a circle on the ring, its shadow does not go beyond the edge [of the ring]. Consequently, this device matches the heavens when placed on a horizontal plane. The marks above are for the *koku* of the day and those below are for the *koku* of the night.[251] *[This device] fits to [all the] myriad of countries.*'[252]

Based on this description, Nishimura Tōsato attempted to reconstruct this device and make observations. Nevertheless, the result was pure disappointment, and "it did not come out as is described that "sun makes a circle on the ring, its shadow does not go beyond the edge [of the ring]." "It was only during the equinoxes that it worked as Shunkai described it," — complained Tōsato.[253] In the attempt to understand the device he even made a rough sketch of it, but unsuccessful, he gave up saying only that he "would be only happy if somebody later would understand what Shunkai said and prove me [i.e., Tōsato] wrong."[254]

But the problem was probably neither due to Tōsato's incompetence, nor in Shunkai's device, but rather with Tani's description of it. It seems that the device was a mix of an equatorial sundial and an armillary sphere, comprising a single ring positioned parallel to the equator and pierced by a wooden rod pointing to the celestial pole. The ring was connected to two handles that allowed for it to be set to the right angle (in order for the device to work, the angle of the ring's inclination should be equal to the colatitude of the place). The outside of the ring was marked with degrees and inside with hours. The central rod then acted as a gnomon and cast a shadow on a lower part of the ring, indicating the hour. But it was only during the

[251] In fact, during the day the sun casts shadow on the bottom part of the ring hence the day-*koku* should be "below", not "above". Given the fact that the rest of the description was not accurate we can allow the possibility that there is a mistake in the text.
[252] Cited in Nishimura Tōsato, *Sokuryō sho ki no zu* (Illustrations of Various Measurement Devices); also cited in Watanabe Toshio, *Kansatsu Gijutsu*, p. 556
[253] Nishimura Tōsato, *Sokuryō sho ki no zu* (Illustrations of Various Measurement Devices).
[254] Nishimura Tōsato, *Sokuryō sho ki no zu* (Illustrations of Various Measurement Devices).

equinoxes that the upper arc of the ring would cast its shadow *exactly* on its lower half, so that by observing the moment when the shadow of the upper part falls exactly within the border of the ring, "not going beyond it," one could know the exact time of the equinox.[255]

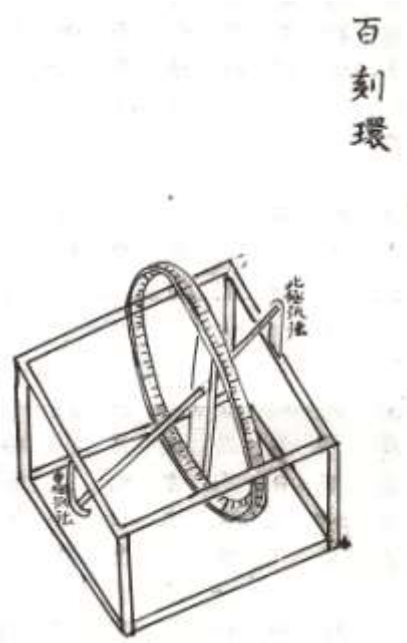

Image 6. Sketch by Nishimura Tōsato in *Illustrations of Various Measurement Devices*. National Astronomical Observatory of Japan.

Shibukawa Shunkai's timepiece was a type of equatorial sundial that enabled adjustment of the device to the latitude of the place it was used at.

So why did Shunkai need this device in addition to the other timepieces he already had? When we look at the structure of this clock, it becomes clear that such a device was not only supposed to produce a measurement of time, as other timepieces did, but it also offered Shunkai a solution to the main problem he was occupied with — the difference between Japan and China. Usually inclined sundials only showed the time of the latitude they were constructed to fit, and Shunkai must have been frustrated with the novel imported devices that failed to stand up to his expectations. It is highly probable that the prototype of this device was imported too, but unlike the previous ones, this time it was a perfect fit — and the device materially confirmed Shunkai's

[255] Albert E. Waugh, *Sundials: Their Theory and Construction* (New York: Dover, 1973).

assertion concerning the importance of geographical difference in astronomical observation and enabled him to measure the local, Japanese time.

Observing the Dawn in Hōreki Reform

Although Shibukawa Shunkai's Jōkyō calendar was highly praised, it didn't take long before the idea of the next reform was conceived. Prominent mathematicians of the beginning of the eighteenth century, Takebe Katahiro[256] and Nakane Genkei,[257] criticized the Jōkyō calendar for its mistakes and miscalculations,[258] and they were not alone. In his treatise *Contemplation about Clocks*,[259] Ōshima Shiran described how the bell-tower came to announce hours on a clearly mistaken schedule that showed "great discrepancies with the heavens."[260] Takebe Katahiro and Nakane Genkei thought that the solution for the problems in the calendar designed by Shibukawa Shunkai lay in the development of mathematical methods for astronomical calculations. Especially, they sought to master trigonometry, detailed explanation of which they found in the Jesuit astronomical literature arriving from China.

As it is widely known, officially Western astronomical literature was banned until 1720, when the eighth shogun Yoshimune[261] lifted the ban as a part of his *Kyōhō Reforms*.[262] Practically, however, Western astronomical literature was present both in the professional and

[256] 建部 賢弘 (1664 -1739).
[257] 中根元圭 (1663-1733).
[258] Watanabe Toshio, *Kinsei Nihon Tenmongakushi*, p. 91.
[259] *Tokei Kō* 時計考.
[260] Ōshima Shiran 大島芝蘭 *Tokei Kō* 時計考 (*Contemplation about Clocks*), 享保十二 (1726), Gakushiin Archive.
[261] 吉宗 (1684-1751, ruling 1716-1745).
[262] A series of economic reforms gradually carried out during the Kyōhō era (1716-1735).

the public realms. Starting from the writings of former Jesuit Chiristóvão Ferreira[263] and Nagasaki astronomers Hayashi Kichizaemon and Kobayashi Yoshinobu,[264] to the extremely popular Chinese *Questions About Heavens*,[265] Western astronomical texts were circulated,[266] discussed and even popularized in Japanese literature by Nagasaki-based scholar and prolific writer Nishikawa Joken.[267] This literature was certainly read by late seventeenth century astronomers and mathematicians, and we certainly see traces of Western theories in Shibukawa Shunkai's writings where he cited *Questions About Heavens*,[268] yet one cannot say that Japanese scholars were particularly overwhelmed by it. Rather, they took it to be something outside of the professional realm of calendrical calculation, as it lacked the most basic features professionals were looking for — calculation methods and numerical data. Thus, for example, Shibukawa Shunkai summarized his attitude towards popular Western astronomical writings by noting that

[263] After the tortures he endured for trying to infiltrate Christian faith into Japan, Chiristóvão Ferreira (c.1580-1650), abandoned his religion and decided to stay in Japan, marrying a Japanese woman and taking a Japanese name Sawano Chūan (沢野忠庵). Although fluent in spoken Japanese, Chuan could not express his ideas in writing and he dictated his (somewhat general) knowledge of Ptolemaic astronomy to a Japanese scholar Mukai Genshō (向井元升) who rendered it into classical Chinese, and naming it *Kenkon Bensetsu* 乾坤弁説 (*Explanation of Heaven and Earth*). In addition to rendering Sawano Chuan's text into legible form, Mukai Genshō also wrote an introduction and commentaries in which he criticized what he perceived to be the shortcomings of Western astronomy. Nakayama, *A History of Japanese Astronomy*, pp. 88-98

[264] Christian convert Hayashi Kichizaemon (林吉左衛門) practiced Western astronomy until he was charged with propagating Christianity and executed in 1645. A student of his, Kobayashi Yoshinobu (小林義信 1601-1684), escaped this kind of destiny, being "only" imprisoned for 21 years, which he spent writing his *Nigi ryaku setsu* 二儀略説(*Abbreviated Explanation of the Two Spheres*), based on De Sphaera, by Pedro Gomez. Nakayama, *A History of Japanese Astronomy*, p. 99.

[265] *Tianqing huowen* 天経或問 (*Questions About Heavens*, Jap. *Tenkei wakumon*) was written by You Yun (游芸), a student of Jesuit missionary Emanuel Diaz but not a professional astronomer himself. Due to the illegal nature of its arrival to Japan, it is not clear when exactly it was brought and when the first copies of it were printed. Yet it is clear that by the last decade of the seventeenth century this book was widely read, even to the point that it was extensively cited in the popular encyclopedia *Wakan san sai zue* 和漢三才図絵 (*Illustrated Sino-Japanese Encyclopedia*), first published in 1713.

[266] Hiraoka Ryuji proved that the previsouly widespread opinion that Jesuit astronomy didn't have much impact is erroneous. Hiraoka Ryuji, "The Transmission of Western Cosmology to 16th Century Japan" in Luís Saraiva and Catherine Jami, ed., *The Jesuits. The Padroado and East Asian Science (1552-1773)* (Singapore ; Hackensack, NJ : World Scientific, 2008).

[267] 西川如見 (1648-1724).

[268] See, for example, Shibukawa Shunkai, *Tenmon keitō* 天文瓊統 (*Astronomical Gem String*) in *Nihon shisō taikei*, vol. 63, pp. 118, 125.

"even though we understand the Western theories, it is impossible to apply them to the [astronomical] practice."[269]

But books that started to arrive from China in the beginning of the eighteenth century were different. Instead of focusing on cosmology, they offered tables based on astronomical observations and described trigonometric calculation methods. The official lifting of the ban on such books was therefore not a turning point but rather a consequence of scholarly interest in these methods.

In 1726 Nakane Genkei set out to add Japanese reading marks[270] to a newly arrived *Encyclopedia of Astronomical Calculations*[271] written by the famous Chinese scholar Mei Wending[272] only a few years earlier. Following this book, Chinese Jesuit astronomical treatises arrived in Japan one after another: the *Chongzhen Calendar*,[273] compiled by Jesuit astronomers Giacomo Rho and Adam Schall von Bell; *Compendium of Observational Astronomy*,[274] which presented Tychonian astronomy; and the visually impressive *History of Instruments Used in the Observatory*[275] that described instruments found in the Imperial observatory in Beijing, designed under the guidance of Jesuit astronomers. Equipped with elaborate illustrations, the book described magnificent astrolabes, sextants, quadrants, telescopes and many others. It is not that these instruments were previously unknown in Japan, yet the grandiose size, the decorations and the exquisite depictions made a huge impression on both the professional and non-professional audience.

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[269] According to Shunkai's student Tani Shinzan, *Shinzanshū* (*Collected Works of Tani Shinzan*) book 34. Cited in Nakayama, *Nihon no Tenmongaku*, p. 75.
[270] *Kunten* 訓点.
[271] *Lisuan quanshu* 暦算全書; Jap. Rekisan zensho.
[272] 梅文鼎 (1633-1721).
[273] *Chongzhen Lishu* 崇禎暦書 ; Jap. Suitei rekisho.
[274] *Lixiang kaocheng* 暦象考成 ; Jap. Rekishō kōsei.
[275] *Lingtai yixiang zhi* 靈台儀象志; Jap. Reidai Gishōshi.

Already in the seventeen twenties Yoshimune became enthusiastic about astronomical observations, and especially about instruments used in such observations. The *Records of the Tokugawa House* describes one such observation. A large telescope was hung diagonally and pointed towards the sun and underneath it a grid was drawn; when a mechanical "tower" clock – a "self-sounding bell" – struck noon, the position of the sunbeam on the grid was measured.[276] It is unclear what the value was of such an observation, since for astronomical purposes it is important to know the exact timing of the local noon, and no mechanical clock of that time could be reliable enough to tell that. Nevertheless, it is symptomatic of both Yoshimune's enthusiasm about observations and his perception of the role of the clock in the process. Rather than recording the time of observable phenomenon, the clock instructed one when to observe it.

Interestingly enough, the same kind of mechanical clock was used by the Nishikawa Masayasu,[277] who was appointed by Yoshimune to design the new calendar. Masayasu was the son of Nishikawa Joken who popularized Western astronomy in his writings. Joken's old age and a subsequent death prevented him from taking this task, but his fame carried over to his son. Masayasu was instructed to continue his father's work and design the new calendar according to the principles of Western astronomy. Yet, "the principles of Western astronomy" had a very specific meaning for both Yoshimune and Masayasu: rather than using the calculation methods of Western astronomy, they focused on the most impressive and easy-to-grasp features found in the newly imported books, namely the observational tools: sextants, telescopes and, of course,

[276] *Tokugawa Jikki* 徳川実記 (*Records of Tokugawa House*), *Yūtokuin dono gojikki furoku kan jūgo* 有徳殿御実記附録巻十五 ("Addendum to the Records of Lord Yūtokuin (Tokugawa Yoshimune) scroll 15"), in *Kokushi taikei* 国史大系 (*Compendium of Japanese History*), vol. 48, (Book 9 of *Records of Tokugawa House* 徳川実記第九篇), (Tokyo: Yoshikawa Kōbunkan, 1934), p. 293; Also cited in Nakamura, Tsukō　中村士, *Edo no Tenmongakusha Hoshizora wo Kakeru* 江戸の天文学者 星空を翔ける (*Edo Astronomers Fly in the Starry Skies*) (Tokyo: Gijutsu Hyoronsha, 2008), p.64.

[277] 西川正休 (1693—1756).

the representative of cutting-edge machinery — mechanical clocks. The presence of the clock, in case of Yoshimune and Masayasu, had more a symbolic than a practical value; the time that it measured was appreciated not for its end-result but rather for the process of measuring itself— mechanical and fashionable.

Masayasu was not the only one responsible for the task of reforming the calendar. The person who was assigned to devise the civil calendar was Abe Yasukuni,[278] a member of Tsuchimikado family, traditionally responsible for the actual compilation of the yearly calendar. The role of Tsuchimikado was not to come up with a better calendrical algorithm, nor to improve the detailed calculations, but rather to use the existing data in order to create a daily calendar for the everyday use of the populace. Nevertheless, Abe Yasukuni did not feel restricted to the calendar compilation alone. He extended his activities to the astronomical observations, and was in constant communication with Masayasu concerning the astronomical side of the calendar compilation process.

In making his celestial observations, Abe Yasukuni also devised his own timekeepers. One of them was a *shaku* clock, which he called the *Seasons-Granting Pole*,[279] referencing the Chinese *Granting Seasons* calendar. This was one of the earliest *shaku* clocks made and clearly represented cutting-edge technology. The clock had a peculiar feature of having both the "civil" hours and the hundred astronomical *koku* represented on the dial, assisting Yasukuni in his task of calendar-making.

[278] 安部泰邦 (1711-1784).
[279] *Jujikan* 授時筒.

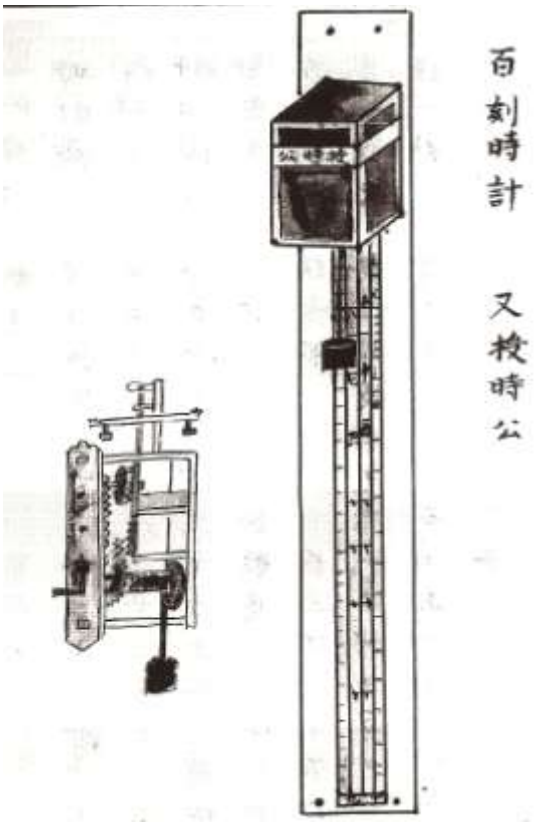

Image 7. A *Hundred Koku Shaku Clock* used by Abe Yasukuni, according to Nishimura Tōsato in *Illustrations of Various Measurement Devices*. NAOJ Archive.

The inscription says "A hundred-koku clock, or *Season Granting Pole*". This was probably a "regular" shaku clock in term of its mechanism and design, but the dial of which also contained an equal hundred units scale, in addition to the variable one.

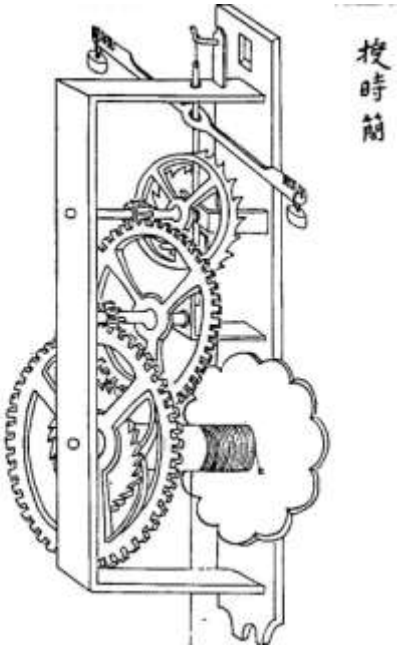

Image 8. "Season Granting Pole", Abe Yasukuni's *New Book on Astronomical Laws* (Rekihō Shinsho).

The mechanism of this clock was no different from other *shaku* clocks of that time.

Yet we should not assume that mechanical clocks simply replaced sundials in astronomical practice. In fact, the timekeeper that Yasukuni used the most was a type of sundial, described in his *New Book on The Calendrical Method*.[280] This instrument, honorifically called *The Dawn Observing Device* [281] is described as a tilted round copper disc pierced by a pointing needle, the upper tip of which is aligned to the south. The disc was comprised of a central spherical concave made of polished copper that reflected the sunbeams. On both the upper and the down side of the disc were drawn eight rings. First two rings on each side were reserved for the measurement of hours in equal units, while remaining rings were made specifically to reflect the variable hour distribution in different seasons. The upper side of the disc would be observed from the vernal equinox to the autumn equinox, when the sun is to the south of the disc; the down side was used during the period when the sun would shine to the north of the disc, namely from the autumn to the vernal equinox.[282] Consequently, by observing the elongated shadow of the pointing needle, Abe Yasukuni could know the time in both the variable units and in equal astronomical units during each of the twenty-four mini-seasons. This shadow-casting needle was carved in the middle to create a fissure, "thin like a line," which only allowed "droplets" of sunlight through. Consequently the shadow cast by the needle onto the ring had a thin bright center, which was taken to point exactly to the hour, "without even a thin-hair-sized difference from the hours set by the Heavens."[283]

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[280] Abe Yasukuni 安倍泰邦 (士御門泰邦), *Rekihō Shinsho* 暦法新書 (*New Book on Astronomical Laws*) 宝暦四 (1754), in Asami Megumi, Yasuda Ken 浅見恵, 安田健 eds., *Nihon kagaku gijuTsukōtenseki shiryō* 日本科学技術古典籍資料 (*Collected Historical Materials of Japanese Science and Technology*), vol 1. "Astronomy" (*Tenmongaku hen,* 天文学篇) (Tokyo: Kagaku Shoin: Hatsubaimoto Kasumigaseki Shuppan, 2001), pp. 160-161, 180.
[281] *Senshigi* 暹胝儀.
[282] *Rekihō shinsho*, p. 160
[283] *Rekihō shinsho*, p. 161

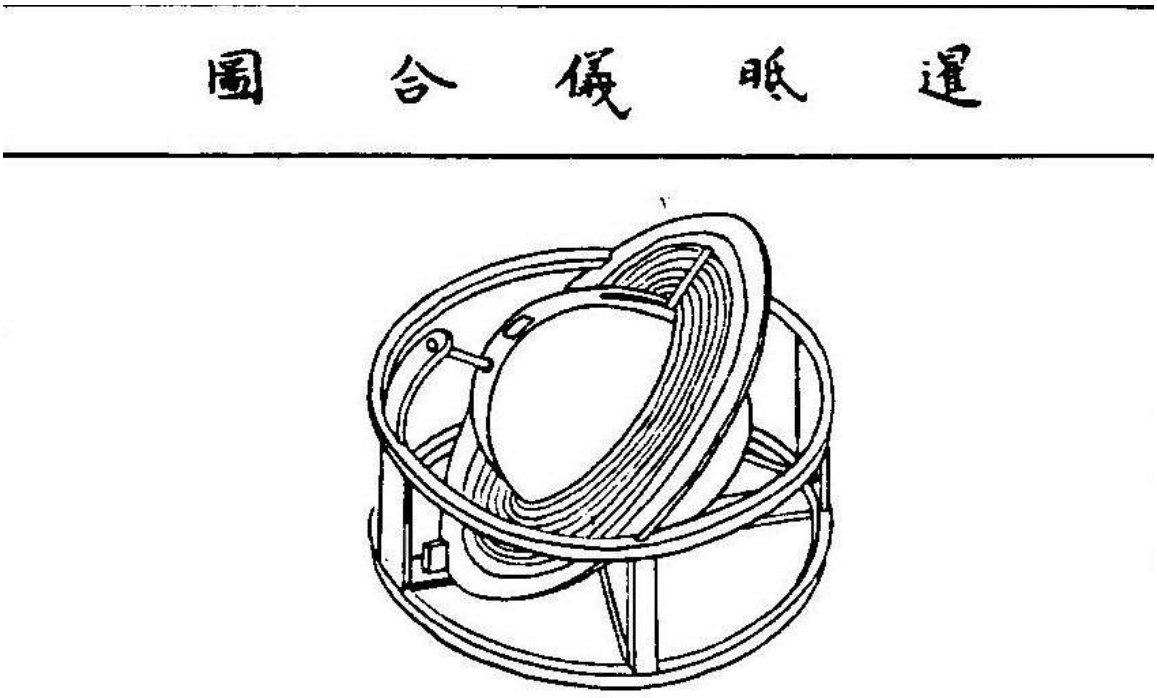

Image 9. Abe Yasukuni's Dawn Observing Device. *New Book on Astronomical Laws* (*Rekihō Shinsho*).

The different "rings" of this sundial were meant to indicate the hours during the different seasons.

Noting Yasukuni's repeated statements that his device matched exactly the "hours set by the Heavens," it is tempting to assume that he was primarily concerned with precision. And he *was* undeniably concerned with precision, but the question is "what sort of precision?"[284] One issue that we can point out immediately is that the smallest unit the clock measured was 1/96th of the day – far larger than units handled in astronomical calculations at that time. So that "not even a thin-hair-sized difference" could be as large as fifteen minutes. But there is more to that than simply the relativity of the notion of precision. Precision for Yasukuni, whose primary motivation was compilation of a proper calendar for general use, was a proper match between astronomical and everyday time-related terms. By observing his sundial, or the *shaku* clock,

[284] As shown in a volume edited by Norton Wise, "precision" can take many shapes and meanings. Norton M.Wise, ed., *The Values of Precision* (Princeton: Princeton University Press, 1995).

Yasukuni could see time in both sets of terms *simultaneously*, making his task of translation between the two systems virtually automatic.

Moreover, this *Dawn Observing Device* was used, as the title suggests, in order to observe the times of the dawn. However, for astronomers trying to establish correct data for new astronomical calculations the crucial element was observation of the shadow length at the local noon. Consequently, the *Dawn Observing Device* was not a *measurement* device, but rather a notifying device, similar in its function to the timekeepers of everyday use. Similar to Yoshimune and Masayasu, Abe Yasukuni was not concerned with acquiring new data, but rather with comparing the existing data with observable phenomena.

The preparations for the reform took much more time than was planned, and the reform was only put in practice in the year Hōreki 4 (1754), thus acquiring the name of the *Hōreki Reform*. But the new Hōreki calendar turned out to be a huge flop. Although during the first year of its use the calculations seemed to fit the observable phenomena, already in its second year the discrepancies were larger than those of the previous calendars, and in 1771 it was unofficially replaced by the so called Shusei calendar.[285] This fact did not surprise professionals at the time. Even before the actual execution of the reform, there was a lot of criticism directed to both Masayasu and Abe Yasukuni, who were deemed to be amateurs, and lacking any astronomical knowledge. The harshest criticism we see in the writings of Nishimura Tōsato, who wrote that Nishikawa Masayasu "didn't study mathematics and could not make any calculations," and "even when he used astronomical devices, he didn't make sure to align them properly on the north-south line, or put them on a horizontal plain." But most of all, Tōsato was critical of the fact that the latter used "only one clock of a hundred *koku* alone, with no special person in charge

[285] 修正. Hisashi Uehara et al, ed., *Tenmon rekigaku shoka shokanshū*, pp. 19-23

of it." And seeing that "it was sometimes ahead and sometimes behind" the easily-observable local noon, Tōsato concluded that it must have produced wrong measurements during the night.[286]

Many historians describing the Horeki reform blame Abe Yasukuni for its failure,[287] saying that although people involved in this reform had a "right" kind of aspiration for using Western astronomy, it was never properly executed due to the latter's dogmatic character. Yet not only was Abe Yasukuni's objection astronomically sound, but he himself used Western instruments in the same way Nishikawa Masayasu did. In fact, it could be said that the failure of the Hōreki reform sprang out of exactly the opposite reason – an over-eagerness to use Western style tools, without really understanding or employing the calculations associated with them.

The Pendulum of Asada Gōryū

Few people were surprised when in the year 1763 the Horeki calendar failed to predict the coming solar eclipse. The least surprised person was Asada Gōryū,[288] who not only predicted that the eclipse would take place, but also calculated the times and the size of it.

Gōryū was born into a high-class samurai family and was destined to serve the lord of Kitsuki domain as a private physician.[289] At the same time, neglecting his official duties, Gōryū

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[286] Nishimura Tōsato 西村遠里, *Honchō Tenmonshi* 本朝天文志 (Astronomy of our country), cited in Watanabe Toshio, *Kinsei Nihon tenmongakushi*, pp. 144-145.
[287] Nakayama, *Nihon no Tenmongaku*, p. 82; Watanabe, *Kinsei Nihon tenmongakushi*, pp.151-164.
[288] 麻田剛立 (1734-1799).
[289] Gōryū was ason of a Confucian scholar Ayabe Yasumasa (綾部安正), Gōryū received the best possible education at that time and was destined to serve the close friend of the family – the daimyo of the Kitsuki domain. Growing up and studying together with the young daimyo, it was only natural that Gōryū would become a prominent official in the domain and he indeed advanced in the ranks of domain doctors, becoming the head physician in 1767. During all these years of his medical career Gōryū never ceased to be interested in his private hobby – astronomy. He continued making observations during his spare time, seeking the regularity and harmony in what appeared to be an overwhelmingly intricate and multi-factored universe. Yet the responsibility to serve his daimyo friend, as well as the obligation to follow the path established for him by his father kept him attached to the medical profession. For a while, Gōryū even focused on medical experiments, dissecting hundreds of cats and dogs,

developed an interest in the Jesuit astronomical books newly imported from China. This astronomy was Tychonian rather than Copernican in its cosmology,[290] and only briefly mentioned Kepler's first two laws. But the importance of this literature lay not in its cosmology, but rather in the calculation methods it offered. Discussing arcs and orbit, Jesuit astronomy introduced trigonometry as a tool to predict future position of celestial bodies. Having studied mathematical treatises by Takebe Katahiro and Nakane Genkei, Gōryū plunged into investigation of novel calculation methods and enhanced his observations to verify the accuracy of those. It was these calculations and appropriate observations that enabled Gōryū to publish an extended critique of the Hōreki calendar in 1762 and correctly predict the solar eclipse of 1763. Eventually, his interests in astronomy pushed him to desert the position and pursue the study of astronomy, earning his living by private tutoring.

It was this background of financial difficulties that brought Gōryū to write repeated letters to Miura Baien and beg for financial assistance to cover the cost of the clock he had ordered.[291] He described the clock as "a very good clock, and there is no other thing that matches it for calculating solar and lunar eclipses. Even if [you] have an armillary sphere, but you don't have this kind of a *shaku*-clock, [you] will not be able to know anything in case it is cloudy."[292] Although the *shaku* clock was already used by Abe Yasukuni, the huge size of this particular one used by Gōryū enabled him to enhance the precision of his observation, since large space on the

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and trying to find inner logic in the structure of their entrails. These medical adventures, as well as the thoughts on his astronomical observations are well recorded in his letter to another student of his father, the famous scholar Miura Baien (三浦 梅園 1723-1789), and in fact could have served as sources of inspiration to the latter's enigmatic natural philosophy. Hisashi Uehara et al ed., *Tenmon rekigaku shoka shokanshū*, pp. 44-45 Letter to Miura Baien from 16th day, 10th month, unknown year.

[290] Namely, rather than fully heliocentric it depicted a universe in which all the planets rotated around the sun, which in turn rotated around the earth.

[291] Hisashi Uehara et al, ed., *Tenmon rekigaku shoka shokanshū*, pp. 34-38, Letters dated 22nd day of the 8th month and 18th day of 11th month. According to the editors, these letters are probably from 1777.

[292] Hisashi Uehara et al, ed., *Tenmon rekigaku shoka shokanshū*, p. 31 Letter to Miura Baien from 22nd day of the 7th month, year unknown.

surface of the dial made it physically possible to have more subdivisions of the day. According to Gōryū, the clock was painted with black lacquer and the subdivisions were scratched on its surface using the thin needle of a compass.[293]

But why did the subdivision of a day not only into 100 *koku*, but also into 1,000 *bu* and 10,000 *byō* became suddenly important? It is not that the smaller units were previously unknown — as we could see Shibukawa Shunkai too used these units in his calculations, and he, in turn relied on terms found in thirteenth-century Chinese calendar. Yet, for Shibukawa Shunkai, the unit of *bu* and certainly that of *byō* were theoretical entities, only used in algebraic calculations. For Gōryū, on the other hand, these units were not only measurable, but also had a physical presence on the clock's dial.

It seems that the different treatment of time-units by Asada Gōryū was a direct result of the change in the type of mathematical calculations performed by him. Unlike his predecessors, Abe Yasukuni and Nishikawa Masayasu, Gōryū was well versed in the newly imported kind of mathematics, having studied treatises on trigonometry written by Nakane Genkei. He also dedicated himself to reading of astronomical treatises arriving from China. Starting from the *Encyclopedia of Astronomical Calculations*, and to *Compendium of Observational Astronomy*, Gōryū swallowed every piece of information about Western astronomy that reached Japan from China.

When reading about these new time-measurement needs in Chinese Jesuit texts, Gōryū unraveled hidden treasure. At the very end of the fourth scroll of *History of Instruments Used in the [Imperial] Observatory*, which described the instruments used in the imperial observatory in Beijing, there were several pages written about a "suspended ball" that could be held by hand

[293] Hisashi Uehara et al, ed., *Tenmon rekigaku shoka shokanshū*, p. 31 Letter to Miura Baien from 22nd day of the 7th month, year unknown.

and made to swing.[294] These swings were constant and could be used for time measurement of the duration of astronomical events. It is not clear when exactly Gōryū started using the pendulum, but in the inventory of the tools he used to observe the eclipse of 1789 we have a description of a "suspended ball" that makes 34,438 swings a day, namely 95.6612 swings for every degree of the sun's apparent motion.[295]

Not only did time units, which previously existed only as theoretical entities, become here tangible and observable, but the subdivision of these units too became more refined. Instead of working with units equal to 1/10000th of a day, one could measure units three times smaller. This development seems to match the standard narrative of increasing technological precision, and there is no doubt that precision was what Gōryū had in mind when working with a pendulum. Yet this increasing precision was different from the previous measurement not only in the degree but also in its nature. Although it appears that both Shibukawa Shunkai and Asada Gōryū measured time, they were, in fact measuring totally different entities. The units used by Shibukawa Shunkai measured enormous cycles of reoccurrences of celestial alignments, while the units used by Asada Gōryū measured distance traveled by celestial bodies. The purpose of measurement, as well as implications of the measurement determined the kind of time measurement that needed to be performed. The small units in the system of Shibukawa Shunkai were needed because of the complexity of various factors that had to be taken into accounts while calculating cycles. The minute swift swings of the pendulum were needed because they translated into distance, so that even several brief swings of a pendulum became a considerable distance when used in astronomical calculations employing spherical trigonometry.

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[294] *Reidai gishōshi,* scroll 4, pp. 31-41. Waseda University Online Collection of Chinese and Japanese Classics (last access April 2012 http://archive.wul.waseda.ac.jp/kosho/ni05/ni05_02683/ni05_02683_0004/ni05_02683_0004.html)

[295] Cited in Watanabe, *Kansatsu Gijutsu,* p. 560.

Consequently, although time measurement in the end of the eighteenth century became much more precise than that at the end of seventeenth century, it was not a result of a natural tendency for more and more precise measurement, nor was it only a result of availability of new technology. This new technology was implemented because it became needed, and it became needed because the time came to be measured for different purposes.

Kansei Reform and the "Suspended Swinging Disk Device"

As already mentioned before, for professional astronomers the failure of the Hōreki calendrical reform was more than predictable. Yet as we have already seen in previous cases, the need for a new calendar itself did not necessarily constitute a good enough reason to initiate a calendrical reform. It had to wait until the next wave of overhaul reforms, this time initiated by Matsudaira Sadanobu, and known collectively as the Kansei reforms.[296] In 1795 Sadanobu summoned Asada Gōryū to design the new system. Under the pretence of old age and illness Gōryū politely declined, suggesting instead two of his head students – Hazama Shigetomi and Takahashi Yoshitoki.[297]

The main novelty of the Kansei calendar was that the times of dawn were defined not in terms of time units of *koku,* but rather in terms of degrees. Specifically, the official moment of

[296] Matsudaira Sadanobu (松平 定信 1759-1829) was a grandson of the previous great reformer and the initiator of the Hōreki calendrical reform, the eighth shogun Yoshimune, Sadanobu missed an opportunity to become shogun himself due to political rivalry. Nevertheless, in a smart move he came to be adopted by the Matsudaira family and through this line became one of "the elders" (老中 *rōju*) at the age of twenty-eight. Shortly after, Sadanobu gained a position of shogunal regent, becoming de facto a ruler of Japanese islands and exercising a series of sweeping reforms, known collectively as "Kansei reforms," named after the era they were implemented in. Kansei era lasted from 1789 to 1801.

[297] 間重富(1756-1816), 高橋至時 (1764-1804). Coming from strikingly different backgrounds, the two scholars were nevertheless close friends and complemented each other's abilities. Takahashi Yoshitoki came from a poor samurai family, gaining an excellent education yet struggling to feed his family throughout his life; Hazama Shigetomi, on the other hand, was a son of a wealthy brewer, who had enough means to entrust the business to another party and dedicate himself to the study of astronomy and to his greatest hobby – building scientific instruments. Consequently Yoshitoki was always a man of theory and calculations, while Shigetomi was a master of measurement and observations.

the sunrise was determined as 7 degrees (*do*), 21 *bu* and 36 *byō* at the latitude of Kyoto.[298] Additional innovation of this calendar derived from Asada Gōryū's law of vicissitudes, which he developed in his *Laws in Time*.[299] According to Gōryū, and unlike the laws of *Granting the Seasons* and that of Shibukawa Shunkai, the length of the year was not only diminishing but actually was based on a 25,400 year cycle.[300] Furthermore, the perihelion, the lunar month, the points of intersection between the sun and the moon orbit – all the values that were taken to be constants, were in fact changing and also had cycles. Consequently, according to Gōryū's astronomy, any calendar had to be constantly revised based on observations and subsequent geometrical calculations.

The reform was devised in less than a year and implemented already in the year Kansei 10 (1796). Yet the work of Takahashi Yoshitoki and Hazama Shigetomi was far from over. In fact, it seems that already during the period that the two were working on the Kansei reform, the seed of the following reform was sown. At that time, the two were introduced to the 1742 *Sequel*[301] to the *Compendium of Observational Astronomy* which rather than relying on a Tychonian framework introduced Kepler. According to the memoirs of Hazama Shigetomi's son, by reading this book in 1797, Asada Gōryū was so distressed that calling himself an old idiot he wanted to burn his *Laws in Time*, and had to be physically restrained by his faithful students from performing this act of desperation.[302] Although the book was spared this tragic destiny,

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[298] Watanabe Makoto 渡辺誠, *Kanazawajō jōshō no yakuwari to jikokuseido no hensen* 金沢城城鐘の役割と時刻制度の変遷について("On the Tranformaitons of Time Systems and the Role of the Castle Bell of Kanazawa Castle") in *Edo no Monodukuri* 江戸のモノづくり (*Artisanship of Edo period*) (Tokyo: Seika Hōkoku, 2006), p. 51.

[299] *Jichūhō* 時中法.

[300] Nakayama *Nihon Tenmongakushi*, p. 120.

[301] 後編

[302] Hazama Shigeyori 間重新, *Senkō taigyō sensei jiseki ryakki* 先考大業先生事迹略記, cited in full in appendix to Watanabe Toshio 渡辺敏夫, *Tenmonrekigakushijō ni okeru Hazama Shigetomi to sono ikka* 天文暦学史上にお

Gōryū could not find the strength to make corrections to his project, and it was up to his students to do so. The realization that their knowledge of Western astronomy might be incomplete or outdated motivated Takahashi Yoshitoki to try his hand in translating Lalande's *Astronomie* that arrived in Japan in the form of a Dutch translation and was purchased by the government for an astronomical sum of money.[303] This project was the first translation of Western astronomy by a professional astronomer, yet it was not completed until several decades after Yoshitoki's death.

Hazama Shigetomi, too, had his hands full working on turning the swinging pendulum of Asada Gōryū into an automated device.[304] According to the memoirs of his son, Shigetomi "read in *The History of Instruments Used in the [Imperial] Observatory* explanations about the pendulum, grasped its principle, and after thinking it through, he realized that there is regularity in the number of minute pendulum swings. By discovering the way to employ this natural movement by combining the hanging pendulum with mechanical gears, he created this device. He called it *The Suspended Swinging Disk Device*,[305] and with it he developed guidelines for a precise measurement of the time of celestial motions." [306]

So what kind of device was it? Another student of Asada Gōryū, Nishimura Tachū,[307] describes it as follows: "On the front side of the box that stores the gears, there are three copper wheels of various sizes. Attached to the axis of the machine, each one of them rotates; the upper

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ける間重富とその一家 (Hazama Shigetomi and his house in the history of astronomy) (Tokyo: Yamaguchi Shoten, 1943), p. 455.

[303] Watanabe Toshio, *Tsūshi*, p. 230.

[304] The sources actually disagree concerning the identity of the inventor of the pendulum clock, and at least one source from the 1830s attributes it to Asada Gōryū. Nevertheless, Watanabe Toshio argues that it was Hazama Shigetomi who invented the mechanical device, while Asada Gōryū only used a pendulum. Watanabe, *Kansatsu Gijutsu*, pp. 559-561.

[305] Suiyōkyūgi 垂揺球儀.

[306] Hazama Shigeyori, *Senkō taigyō sensei jiseki ryakki* cited in appendix to Watanabe, Toshio 渡辺敏夫. *Tenmon rekigakushijō ni okeru Hazama Shigetomi to sono ikka* 天文暦学史上に於ける間重富とその一家 (*Hazama Shigetomi and his family as seen in the history of astronomy and calendar making*) (Kyoto: Yamaguchi Shoten, 1943), pp. 452-453.

[307] 西村太冲 (1767-1835).

level one counts hundreds, the middle one thousands and the bottom one registers the ten-thousand –digits. On the sides of the bottom wheel there are [two] small sections that follow the rotation of the upper three wheels, and automatically[308] show the counted time in characters and [hour] numbers." [309] The structure of this multi-faceted dial suggests that the main function of the device was to measure time in arbitrary units that did not correspond to any temporal system – roughly 60,000 swings per day, counted starting from the local noon. After all, the number of the swings did not really matter; as long as it was constant, it only had to be divided by 360 to find out how many swings represent one degree of celestial motion. On the other hand, the function of "translation" into units meaningful to humans, which was so central in the astronomy of Abe Yasukuni, was barely given any attention here. Although the machine automatically provided the hour count in astronomical units, the hundred-*koku shaku* clock was hidden inside the box containing the pendulum, suggesting that it was only a minor function, an addendum to the main purpose of the device.

In fact, this count of oscillations disregarded both the common system of twelve variable hours, and the decimal astronomical system of one hundred daily units altogether. What mattered here was only the raw number of oscillations counted from one designated moment to another. The time of the pendulum clock was quite different from any other time systems that existed in Japan prior to it. It wasn't defined as measuring portions of a day, because the calculations made by astronomers didn't measure events in relation to specific dates, celestial events or the length of the year. Rather they just measured the arc between two points in the skies, and for this

[308] Although the expression "自然ニ" is usually translated as "on itself", I think that in this context of mechanical function this expression would be adequately translated as "automatically".
[309] Nishimura Tachū 西村太沖, *Shitendai sho ki zu* 司天台諸器図 (Illustrations of various instruments in observatory) Waseda University online Collection of Chinese and Japanese Classics (http://www.wul.waseda.ac.jp/kotenseki/html/ni05/ni05_00645/index.html last accessed April 2012).

purpose they only needed units of constant length, regardless of what length it was. The time of the *Suspended Swinging Disk Device* was the time of the period of the pendulum.

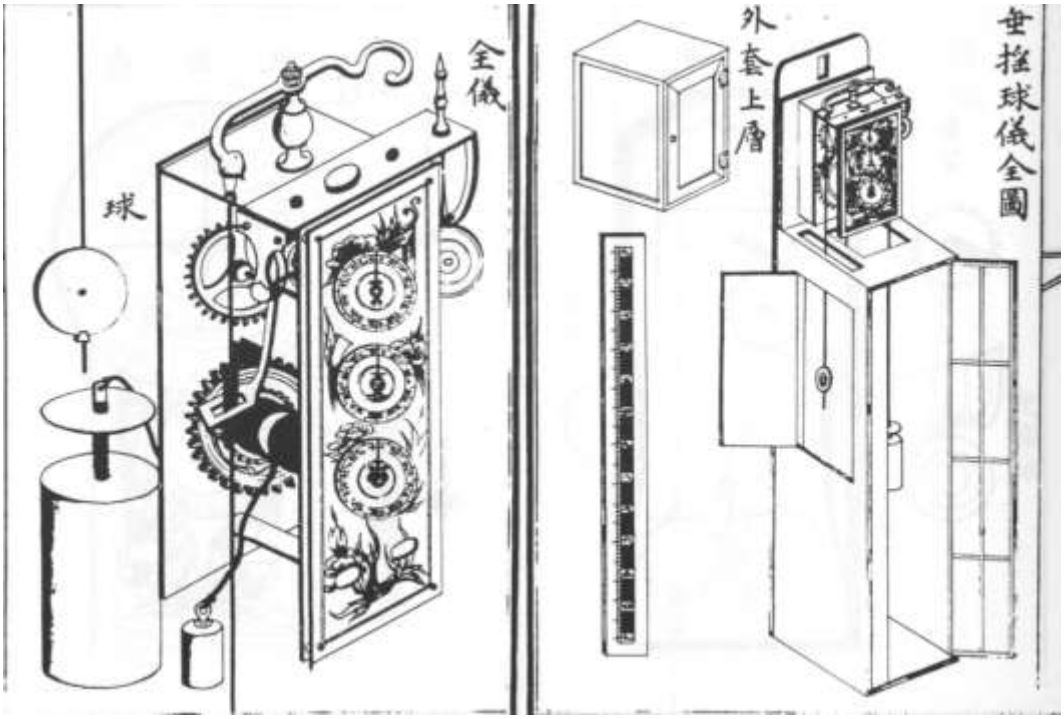

Image 10. *Suspended Swinging Disk Device*. From Shibukawa Kagesuke *The Book of Kansei Reform.*

The Illustration on the left depicts the astronomical dial, while the illustration on the left shows that the box holding the weights also had a dial to count variable hours.

The structure and the specific function of this time-keeping device not only reflected the needs of astronomers, but were also crucial to the social setting of astronomical observations. Although scholars such as Shibukawa Shunkai, Nakane Genkei, and Abe Yasukuni were usually surrounded by their students and apprentices during their observations, they could, and sometimes did make observations in solitude. The pendulum clock of Hazama Shigetomi, however, turned this process into an inherently communal enterprise. If a lone astronomer was engaged in observing an eclipse, then trying to mark the exact time of the beginning of an eclipse

on one's own would have resulted in the loosing of several precious swings of time.[310] In order to avoid that, the observation required cooperation and even synchronized action of several observers.

For example, one person would focus his attention on the approaching eclipse and shout to the clock keeper, whose eyes were fixed on the dials, to start and later finish the time count. In another case an observer would use a sextant to mark the altitude of a celestial body at two different points, asking the clock-keeper to count the time between them. And even the calibration of the clock according to the local noon required the help of an additional person – a keeper of a *Meridian (Rat-Horse Line) Device*, who would shout to the clock keeper at the moment when the sun is exactly over the meridian.[311] Since it was always used in conjunction with the *meridian device* and the sextant, the three devices were considered inseparable and often referred to in a single word sextant-meridian-line-pendulum-device — *shōgenshigosensuiyōkyūgi*.[312] Simultaneity produced by this collaborative human effort was, of course, not even close to the modern day, mechanical simultaneity;[313] neither did late eighteenth century Japanese astronomers have an explicitly formulated notion of 'personal equation'; yet the awareness of time that would be lost in transmission from one instrument to another nevertheless shows that this notion existed, and posed an ideal that encouraged more and more precision.

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[310] We see here a certain degree of similarity to the case described by Simon Schaffer in "Astronomers Mark Time", *Science in Context*, 2, 1 (1988), pp. 115-145. The division of labor between several assistant observers served here as a means of controlling and increasing precision of measurement.

[311] Shibukawa Kagesuke 渋川景佑, *Kansei Rekisho* 寛政暦書 (*The Book of Kansei Calendar*), 安政六 (1859), reprinted in Asami Megumi, Yasuda Ken, ed., *Nihon kagaku gijuTsukōtenseki shiryō. Tenmongaku hen*. Vol. 2., pp. 425-429.

[312] 象限子午線垂揺球儀. For details about the use of these devices see chapter four.

[313] Of the type described by Peter Galison in *Einstein's Clocks, Poincare's Maps: Empires of Time*, New York; London: W.W. Norton, 2003

The True Time of Kaga Domain

If other astronomical timekeepers mentioned in this chapter were unique and singular, the *Suspended Swinging Disk Device* proved to be different. Immediately after construction of the first device, Hazama Shigetomi introduced it to his numerous friends and colleagues motivating them to order similar devices. It is unknown how many pendulum clocks of this kind were made in the beginning of the 19th century but we do know that today there are four surviving exemplars.

One of the people who learned of the *Suspended Swinging Disk Device* from Hazama Shigetomi was Endō Takanori,[314] an official of Kaga province (currently Kanazawa) in charge of infrastructure. Takanori's main projects were land surveying and mapping, but in an attempt to improve the existing maps Takanori also started dealing with tangential topics such as measurement instruments, linear perspective, astronomical observations and time measurement. It is perhaps Takanori's achievements in these various fields that inspired the daimyo of Kaga to order him to reform the local calendar. Calendrical reform of the Kaga domain was not one of the official reforms of Edo period, and naturally, was restricted to one region only. Yet the peculiar time system used in Kaga, as well as creativity of Endo Takanori in devising and employing timekeeping devices, makes this (failed) reform worthy of our attention.

Unlike the rest of Japan, the people of Kaga domain had not twelve, but thirteen hours in one day. They still used the twelve animal signs and the two consecutive series from nine to four in order to count the hours; and they too divided the day into the daytime hours and the night-time hours, so that all the hours were of variable length. The peculiar feature of Kaga calendar

[314] 遠藤高璟 (1784-1864).

was an inclusion of an "addition"[315] prior to the sunrise and after the sunset. Although this "addition" was supposed to fit in the slot of half an hour, it actually lasted the length of a full hour, so that the two "additions" consequently added one full hour to a day. It is not clear how exactly this system worked prior to the nineteenth century; whether the bell specifically indicated this "addition," and if so, by what number of strokes. Yet, early nineteenth century sources all claim this calendar to be very "imprecise" – a feature that obviously caused the lord of the domain, Maeda Narinaga,[316] to seek the help of Endo Takanori and reform the local calendar to adapt it to the rest of Japan.

As already mentioned before, there was no lack of good reasons for lord Maeda to choose multi-talented Takanori for the job of reforming the calendar. Yet one additional reason could have been the fact that during his astronomical studies, at the age of fifteen, young Takanori investigated the structure and the measurement of previously existing sundials in Kaga province. Takanori compared the measurements of these sundials with the calculation of hours based on astronomical measurements he learned from his teacher Nishimura Tachū, and tried to explain the discrepancies between the two. It is mainly because of this work of Takanori that we know anything of the pre-19th century Kaga time system, which was not otherwise described.

It is worth mentioning that Takanori's teacher, Nishimura Tachū, was a direct student of the author of *Illustrations of Various Measurement Devices*, Nishimura Tōsato, and at the same time is considered to be a member of "Asada school" together with his friends Hazama Shigetomi and Takahashi Yoshitoki. This web of scholarly (as well as personal) connections helps explain the circulation of imported literature, newly developed astronomical theories and calculation methods, mutual interests and most important for us – astronomical instruments.

[315] Jap. *amari* 余.
[316] 前田斉広 (1782-1824).

Takanori benefited from all the worlds – he inherited the interest in measurement instruments from Nishimura Tōsato; his astronomical attitude was shaped by the theoretical basis of the Kansei calendrical reform shaped by the scholarship of Asada Gōryū; he was updated with the most recent Western astronomical knowledge by his teacher Nishimura Tachū who worked with Takahashi Yoshitoki on the translation of Lalande; his knowledge of surveying methods benefited from the collaboration with Takahashi Yoshitoki's famous student – the geographer Inō Tadataka; and he had learned from Hazama Shigetomi about the use and construction of the pendulum clock — *The Suspended Swinging Disk Device*.

Many of these intellectual influences were reflected in the structure of calendrical reform devised by Takanori — a reform that attempted to create a precise calendar based on principles of the Kansei Reform and at the same time suited to the geographical location of Kaga province. Similarly to the Kansei calendar, Takanori determined that the times of sunrise and sunset would be specified not in time units but rather in degrees of the sun's motion. However, unlike the Kansei calendar which determined the moment of sunrise as the sun's position 7.36 degrees below the horizon, Takanori decided on the sunrise as the sun's position at 13.6974 degrees below the horizon, to include the "addition" in the normal hour count. Consequently, the day in Kaga province always started when it was still completely dark. In another example, similar to the customary system in all of Japan, the new calendar in Kaga province did not change the actual length of day and night hours on a daily basis, but rather according to the yearly mini-seasons (*sekki*). Yet unlike the rest of Japan, that used twenty-four mini seasons to do so, under Takanori's calendar the Kaga domain came to use twice as much — forty-eight mini seasons, each of which reflected the seasonal change in the length of night and day.[317]

[317] Watanabe Makoto, *Kanazawajō jōshō no yakuwari to jikokuseido no hensen*, p. 64.

Interestingly enough, whereas in the case of sunrise Takanori preferred to adjust the system to the local custom rather than celestial motion, in dividing the year into more seasonal units he aspired to follow the natural cycle as closely as possible. In similar fashion, rather than determining noon to be an artificial point reflecting the local noon of Kyoto – a customary practice in the rest of Japan, Takanori devised his new calendar around the precise measurement of the local noon of Kanazawa, the capital of Kaga domain. Highly attuned to the geographic, climatic and cultural characteristics of his domain, Takanori sought to devise a calendar that would *precisely* reflect peculiarities in his region, even naming his new calendrical system *The True Time*.[318] In this sense, he too sought precision, yet this was precision of a slightly different kind – the mechanical precision of the timekeepers themselves and their ability to measure celestial motion in minute units was not the goal in itself and was not evaluated in either mechanical or astronomical terms, but rather served as a means of reflecting the natural and cultural characteristics of specific locality.

To achieve this local precision Endo Takanori engaged the use of not one, but three timekeepers concurrently. Unsurprisingly, although all three kinds of timekeepers were meant to measure time, broadly speaking, each one had a different function, thus effectively measuring a different kind of time. The first timekeeper was a sundial devised by Takanori himself and named *Sun-rays Measuring Plate*.[319] This was a type of equatorial sundial and Takanori himself noted that it was somewhat similar to the device used by Shibukawa Shunkai. It consisted of an inclined round plate, which was set on a tripod and aligned to face north. The pointer axis was perpendicular to the plate with a silken string running between its highest and lowest points and to the southernmost edge of the plate. This axis could be used to tell the daytime hours, as any

[318] *Shōjikoku* 正時刻.
[319] *Sokkiban* 測晷盤.

other sundial; however, the major use was made of the triangle of silken string stretched from it. According to his records one would note the moment when the shadow from all the strings creates one single line in order to know the exact moment of the local noon.[320] Conversely, on cloudy days, one could look directly at the direction of the sun from beneath the strings and note the moment when the sun is exactly above the meridian. In fact, this triangle of strings is the same exact structure as the *Meridian Device* used by creators of the Kansei calendar – a structure that was meant to determine the moment of passage of the sun or other celestial bodies above the meridian, namely the celestial north-south line, or in Japanese direction terms "rat-horse line".

This measurement of the local noon was essential for calibration of another clock – a precision pendulum clock. Although modeled on Hazama Shigetomi's *Suspended Swinging Disk*, Takanori's *Board of True Time*[321] was nevertheless slightly different. The mechanical part of this device was similar to the *Suspended Swinging Disk*, but it only counted ten thousand units a day, and had a slightly different display. In the former, the main focus was on the front panel dials that counted minute swings of the pendulum, and although it had a dial that showed "everyday" hours, this dial was hidden from immediate view inside the box that contained the weights and the pendulum. But in the *Board of True Time*, the graph-like dial that indicated the everyday hours was exposed, occupying the central and most visible position on the front panel. The reason behind these variations of the pendulum clock becomes clear when we consider the purpose for which the clock was used. Unlike the *Suspended Swinging Ball*, which was used to measure time for astronomical calculations, the *Board of True Time* was meant to keep *precise everyday time*. If previously the minute units were made necessary by the nature of astronomical

[320] Endō Takanori 遠藤高璟, *Takezawa goten soku koku go kibutsu yōhō* 竹沢御殿測刻御器物用法 (The method of use of time measurement devices of lord Takezawa), 文政六 (1823), Kojū Bunko Archive.
[321] *Shōjiban* 正時版.

practice and only meant to facilitate the *creation* of a calendar, Takanori's idea was to employ a precision timekeeper to *maintain* precise time in civil life. This was the reason that he did not need to go beyond the ten-thousandth division of the day, since any smaller division simply wouldn't have been visible on the dial. And this was the reason behind the focus on the graph-like detailed dial – it was supposed to be read by a bell-keeper, not by astronomer per se. Takanori not only wanted to *devise* a precise calendar, he also wanted the people of his domain to actually *live* according to precisely measured time.

Yet if this was the goal, then why did Takanori advise the use of an additional, third timekeeper - a "normal" by that time, single-balance, "tower" type mechanical clock - a *jimeishō*, or "self sounding bell"? After all, the precision level of these clocks was considerably lower, and Takanori was well aware of it. But in fact, this "approximate" measurement of time was exactly what Takanori needed, and the feature that he was looking for was not the time-measurement itself but rather the clock's bell sounding function. Consequently, the only function of mechanical clock was to alert the bell keeper that it is *about* time to watch the precise *Board of True Time.*

This is how the system worked: In the sixth hour of the morning, namely at the time of sunset designated by the *Board of True Time*, the bell keeper would ring the bells but also adjust the weights on a big clock to measure day hours appropriate to the seasons, in the next hour he would do the same to a small clock, so that the bell keeper could notice if the big one was slightly off. In the next hours, the bell keeper would listen to the signal of clocks and compare the measurements of the *Board of True Time* to those of *Sun-rays Measuring Plate* sundial. When the two clocks sounded noon, the bell keeper would calibrate the *Board of True Time*

according to the exact moment of the local noon shown by the sundial.[322] Consequently, although the three types of timekeepers all measured time, each one of them measured different kinds of time: the sundial measured the local noon, the "true" time of the region; the pendulum clock measured precise time to maintain the "true" time during the rest of the day; and clocks measured approximate time – the time of human attention. Using this system, Takanori hoped to make the people of his domain live by the "true" time of their region.

This system had one obvious disadvantage – it was useful only for people living in the capital and its surroundings, namely in the range of the sound of the castle bell. What was a traveling official, or even a farmer to do when he was too far from Kanazawa castle to hear the bell? To compensate for this flaw, Takanori devised a portable sundial that could be used everywhere, and called it *Sun-rays Measuring Tile*.[323] The idea of a portable paper sundial was far from new, of course, and we have already seen simple paper sundials in the second chapter. Nevertheless, the seasonal graph of this specific sundial was made based on astronomical calculations taken by Takanori, elevating this device from a rough estimation to a "precision sundial". By mass producing this kind of sundial, Takanori was hoping to achieve the maintenance of "true" time in the whole of the domain.

Endo Takanori's reform was short lived. People found the abolition of the "addition" unit confusing, and complained about the chaos the new system brought to the old, and well calculated working schedules. Less than two years after the implementation of the reform, its most powerful proponent, the lord of Kaga domain Maeda Narinaga, died, leaving Takanori defenseless against prevalent criticism. Following popular demand, the system of thirteen hours was reinstituted and remained in place almost until the Meiji reform. Nevertheless, the precise

[322] Endō Takanori, *Takezawa goten soku koku go kibutsu yōhō*.
[323] *Sokkibai* 測晷牌.

measurement of time and the time-keeping system that was meant to indicate the "true" local time was preserved even with an addition of an "addition."

At first glance, the history of Endo Takanori's time-keeping system seems to fit the usual narrative of the gradually increasing importance of precision. Nevertheless, this case seems to contradict the narrative that attributes the increasing precision to the departure from "natural" modes of life and movement towards the artificial and abstract time of the mechanical clock. Here we see an opposite case: with the advance of technology and availability of precise astronomical calculations, Endo set himself a goal to determine the "true" time according to the movement of the heavenly bodies and true to the regional locality.

Conclusion

There is no doubt that our tendency to view the evolution of timepieces as a story of growing precision is shaped by our knowledge of the end product — precision clocks. Yet there is another factor that limits our attention to the precision alone, and it is our view of timekeepers as devices that were built to measure this abstract and intangible entity — time. If timepieces' only function is to measure "time," then it is only natural to expect that with the time, and with more and more experience in the making of timekeepers, this function will improve, the devices will become more reliable and the units in which time is measured will become smaller and smaller.

At first glance, it appears that the astronomical timekeepers of the Edo period confirm this narrative of increasingly precise measurement of time; yet a closer look at the structure of these timekeepers and the practices involved in handling them reveal a different story. Broadly speaking, these devices were not meant to measure "time", because time-measurement without

purpose is meaningless. What shaped the timekeeping devices and timekeeping practices was not *time*-measurement, but rather all the various purposes of measuring, keeping and possessing time.

Shibukawa Shunkai employed his adjustable sundial to measure geographical distance from China. Nishikawa Masayasu had a mechanical clock to observe the work of novel Western mechanical technology. Abe Yasukuni used his multi-faceted sundial to measure the time of a civil calendrical event. Asada Gōryū began a revolution in Japanese astronomical practice by employing trigonometry for his astronomical calculation; with his large *shaku* clock, and later with his pendulum, he measured arcs of celestial motions. The time that he and his students measured was only relative to a certain phenomena and therefore, they did not measure "time" as an absolute entity, but rather the time of an eclipse or the time of the passage of a certain planet from one point to another. Therefore, Hazama Shigetomi, the creator of the *Suspended Swinging Disk Device*, embedded in the clock's structure the trigonometric calculations he needed data for, and the ideas associated with "The Law of Vicissitudes" his teacher was working on, but dismissed those aspects related to the civil life. Endo Takanori's purpose, on the other hand, was precisely to establish a civil time that would be "true" to the geographical and cultural characteristics of his domain.

There is no doubt that all of the abovementioned devices *were* perceived as timepieces, since almost every description of these includes a straightforward statement that those are a type of *tokei.* Yet, this generic category cannot conceal the fact that each one of them had different appearance, different function, different character, and different name; and the reason for this differentiation was that each different type of timepieces was measuring different kind of time, with different kind of precision.

These different "times" were defined by practices and assumptions outside of the strict area of time-measurment, but which were deemed relevant by astronomers and thus carried over from other spheres into time-keeping. It was up to specific astronomers to decide what exactly was relevant for time-keeping and which calculating practices should apply to it, and it was these individual decisions by astronomers that shaped the variety of astronomical "times".

This process, however, was not a one way borrowing from mathematics to timekeeping. In the same manner that astronomers carried over their calculation practices into the sphere of timekeeping, they also employed practices developed in timekeeping for other purposes, effectively changing the social settings of Edo-period astronomy. The time of the pendulum clock was shared. As an astronomical tool, it was useless unless used it together with additional devices, and consequently in collaboration with several additional astronomers. As a result, astronomical observations could no longer be done by a lone astronomer, and called for a temporal collaboration. Moreover, time was shared not only in one particular instance of observation, but it rather was created as one shared and exclusive time of astronomical observations. By setting the standard of time measurement on the number of oscillations, the pendulum clock provoked a makeover in the recording method of observational data, so that anyone who wanted to use existing data (which is practically unavoidable in astronomy) had to adhere to the pendulum standard. Yet the mere knowledge of the clock, its design and use were in the possession of one group of astronomers centered on Takahashi Yoshitoki and Hazama Shigetomi, so that anyone who wanted to use the clock, he had to be personally connected with them. Consequently, the knowledge of the *Suspended Swinging Disk* system, as well as possession of the actual device, de facto delineated the astronomical community of late-eighteenth and early nineteenth century. In the same manner that specific kind of astronomy

shaped this specific type of clock, the clock was employed in reshaping the body of late eighteenth and early nineteenth century Japanese astronomy.

Chapter 4: Time to Travel

Introduction

Previously we have seen how astronomical time was constantly redefined by astronomers' calculation practices. Namely, by carrying over practices and associations from tangential areas to the sphere of timekeeping, users constantly redesigned their timekeeping technologies, their handling of these technologies, and the conceptual implications that derived from them.

At the same time, timekeeping practices themselves were carried over to related fields, and used as creative means for change. Already in the previous chapter we saw how pendulum clocks provided material venue for reorganization of the social setting of astronomical observations by enforcing coordination between several participants. The current chapter continues to examine this process of carrying over certain practices and assumptions from one field to another by focusing on the transformation in the Japanese concepts of space and time in the course of the first half of the nineteenth century. Exploring the role clocks played in land surveying, we will trace the ways clocks helped to redefine the perception of geographical space as time-based continuum. And following the expansion of geographical exploration into the uncertain space of an open sea we will see how hypotheses about marine timekeeping facilitated the transformation in the notion of time itself, which came to be conceived of as universal, independent, and represented by mechanical marine chronometers.

Geography

Our story in this chapter begins with concern that had very little to do with an actual physical space, and had no relation to time measurement or clocks. Rather, it all started with the calculation troubles of Takahashi Yoshitoki – one of the architects of Kansei calendrical reform whom we have already met in the previous chapter. Already by the time the new calendrical system was administered in 1795, Yoshitoki knew it was far from perfect. His miscalculation of an eclipse, which occurred seven minutes later than predicted, proved that his suspicions were well grounded. Among the factors that could have skewed his calculations was the uncertainty in the actual length of one degree of meridian. The various Jesuit astronomical treatises imported from China[324] gave different values, measured in traditional units of *ri*.[325] Some suggested it was 32 *ri*, others 30 or even 25. Even worse, was the fact that it was not exactly clear how long one *ri* was. In Japan, one *ri* was equal to 12960 *shaku*[326] but there were also different opinions about the length of one *shaku*, which could be (in modern-day terms) 29.6cm, 30.258cm, or 30.363cm. But Yoshitoki also knew that the values of Chinese units of length were altogether different, and one Chinese *ri* (or *li*, in Chinese) was equal to only 1500 *shaku*, also of undecided length.[327] Translating all of these uncertainties into modern terms, the length of one degree of the meridian could be as large as 126 kilometers (78 miles) or as small as 10 (or 6.5 miles).[328]

Furthermore, Yoshitoki may have already encountered the idea of the non-spherical shape of the earth, which suggests that the length of one meridian degree changed with the

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[324] Particularly *Lixiang kaocheng* 曆象考成 (*Compendium of Observational Astronomy* Jap. Rekishō kōsei)
[325] 里
[326] 尺
[327] Ōtani, Ryōkichi, *Tadataka Inō*, Sugimura Kazue, trans. (Tokyo: Iwanami Shoten, 1932), p. 46.
[328] Japanese astronomers were not the only ones concerned with this disarray of standards. As Ken Alder wonderfully described in his *The Measure of All Things* (New York; London: Free Press, 2002), the French astronomic community was troubled by the same concerns at about the same time.

distance from the equator. This meant that Yoshitoki could not trust *any* of the foreign values at all, since it was impossible to know whether those were measured at the same latitude as that of Japan.

A solution for this problem was inspired by one of Yoshitoki's students—Inō Tadataka.[329] Inō was an unusual student. Born into a high-class yet very poor family, he later married a widowed daughter of a local brewer and given the task of saving the family's fortune. He was quite successful, gradually gaining not only wealth but also high-ranking position in local management. As a part of his duties and business, he traveled extensively between his native village of Sawara[330] and Edo, gradually becoming interested in the terrain he saw, and attempting to survey it based on the techniques he learned from the available popular surveying guides.[331] His life changed when in 1795, at the age of fifty, he decided to leave his business and village management to his older son and travel to Edo to study astronomy under Takahashi Yoshitoki, who was twenty years his junior. Owing to his exceptional position as a wealthy and older student, Inō proceeded relatively quickly through the regular curriculum which included the Jesuit treatises such as *The Instruments Used in the [Imperial] Observatory* and *Compendium of Observational Astronomy,*[332] but also the seventeenth century Japanese *Jōkyō Calendar*[333] and

[329] 伊能忠敬 (1745-1818), Since in Japanese literature it is customary to refer to him by his last name, I will follow this fashion.
[330] Located in the vicinity of Narita International airport today.
[331] Murai Masahiro 村井昌弘, *Ryōchi shinan* 量地指南(*A Guide to Land-Measurement*), 享保十七, (1732); Mao Tokiharu 万尾時春, *Kikubuntōshū* 規矩分等集 (*Anthology of Divisions Made with Compass, Ruler and the Such*), 享保七, (1722); and Shimada Dōkan 島田道桓, Chōken bengi 町見辨疑 (*Problems and Solution to Measuring Length*), 享保十 (1725), all of which were listed in Inō's library.
[332] Ch. *Lingtai yixiang zhi*, Jap. *Reidai Gishōshi* 靈台儀象志; Ch. *Lixiang kaocheng*, Jap. *Rekishō kōsei* 暦象考成.
[333] 貞享暦. Written by Shibukawa Harumi (渋川春海) before 1684. For detailed discussion of this calendrical system see chapter four.

the thirteenth century Chinese *Granting the Seasons* calendar,[334] which Yoshitoki considered to be the basis of any astronomical knowledge.

Inō's surveying aspiration provided Yoshitoki with an exceptional opportunity to resolve the problem of the length of one meridian degree by straightforwardly measuring the geographic distance alongside with the measurements of latitude. At first, Inō measured the distance and the latitudinal difference between his native Sawara and the Astronomical Bureau in Edo, but the distance was too short and he feared that marginal inaccuracies in measurements could amount to a considerable error. Consequently, Yoshitoki encouraged Inō to make a surveying trip to the north of Japan, reaching as far as the northern island of Ezo (modern-day Hokkaidō).[335]

To enable such a mission, Yoshitoki and other influential acquaintances of Inō petitioned the government to sponsor the trip and make it an official mission. Yet the government hesitated, not sure of the practical value of such a trip and worried about the enormous cost of this kind of expedition. Inō, who subsidized all of his studies out his own pocket and spent a considerable amount of money ordering customized measurement instruments, now faced the possibility of his mission being cancelled because of the budget. Seeing that, he offered to pay for most of the expedition himself, even though he had to cut the number of people who accompanied him. The government accepted the offer, providing Inō an official stamp for the mission and a modest stipend. For an affluent person like Inō the government stipend itself was not the most crucial

[334] 授時暦 Ch. *Shoushili*, Jap. *Jujireki*.

[335] In terms of surveying and observational methods, this mission is very similar to Maupertuis' expedition to Lapland described by Mary Terrall in *The Man Who Flattened the Earth: Maupertuis and the Sciences in the Enlightenment* (Chicago: University of Chicago Press, 2002). In the goals of the expedition, however, this case is reminiscent of Delambre's and Méchain's measurement of France's portion of meridian described by Ken Alder in *The Measure of All things* (New York; London : Free Press, 2002).

factor, since following his efforts the expedition was far from being underfunded.[336] What mattered the most was the government seal that granted the expedition party priority on the roads, and the promise of cooperation with local inns.[337]

In May 1801, accompanied by his surveying assistants, Inō set out on his trip to the north, stopping along the way to make measurements. The expedition headed north through the main island of Honshu, crossed the sea to reach the northern island of Ezo and surveyed a southern coast of the island before heading back. We know most of the surveying process from the extensive surveying diary Inō kept, the surviving parts of which amount to several modern day volumes.[338] The specific surveying techniques are described in his numerous writings, as well as and in short treatises his students wrote about his methods.[339] Looking at the described techniques, we can see that there was nothing in what he did that was not used in Japan before — most of the surveying was done using the traverse and the intersection methods of land surveying. The actual measurement of length was done sometimes with a perambulator (when conditions permitted), by pacing with an odometer, or just by laying ropes and chains. In order to make the measurements consistent, Inō adopted one standard length of *shaku* – 30.34cm.[340]

The innovation of Inō's expedition, however, lay precisely in the original motivation for the whole mission – conducting astronomical observations alongside the surveying. And it was

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[336] In this sense, Inō's expedition was nothing like "lightly equipped, underfinanced, more or less solitary" expedition of Robert Herman Schomburgk described by Graham Burnett in *Masters of All They Surveyed*, (Chicago: University of Chicago Press, 2000). Citation from p. 3.
[337] Otani, *Tadataka Inō*, pp. 79-81.
[338] Inō Tadataka 伊能忠敬, *Sokuryō nikki* 測量日記 (*Surveying Diary*), Sakuma Tatsuo 佐久間達夫 ed., (Tokyo: Ōzorasha, 1998). Seven volumes.
[339] A good example is *Ryōchiden shuroku* 量地伝皆録 (*All Records of [Inō Tadataka's] Methods of Land Surveying*), written by Inō's student Watanabe Shin 渡辺慎 in 天保二 1831, National Diet Library.
[340] Which is the value given to this ancient unit in dictionaries today, and is known as *Inō-shaku*. In determining this value, Inō was probably influenced by his other teacher, Hazama Shigetomi, who conducted a detailed historical investigation of measures and values of Japan, which unfortunately was lost already sometime in the nineteenth century.

this combination that paved the way for the transformation in the perception of time-space relation, and eventually of the concept of time as a whole.

By the beginning of his journey, Inō was equipped not only with the latest astronomical theories and mastery of trigonometric calculations, but also with a series of novel astronomical devices. His made-to-order theodolites for measuring the azimuth of key landmarks proved to be crucial for the precision of his measurements.[341] Nevertheless, for the purposes of the current study, Inō's most intriguing instrument was his pendulum clock — the same kind as the *Suspended Swinging Disk Device* invented by Hazama Shigetomi and used by Takahashi Yoshitoki.[342] There is actually no specific record in Inō's diary describing how exactly the clock was used, yet there is no doubt that he used a pendulum clock both because he recorded the results of calculations made with time measurements,[343] and because we know that he carried a pendulum clock along a difficult terrain despite its weight and size. The clock he used is still preserved in the museum dedicated to Inō's work,[344] and similar clocks used by other astronomers-surveyors have also survived to this day.[345] Moreover, it is possible to reconstruct the process of pendulum measurements from the letters Yoshitoki wrote to amateur astronomers seeking his advice[346] and from the description of Yoshitoki's practice itself.[347]

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[341] Inō's theodolites, and especially the small theodolite with reversed east-west directions, are definitely worthy of further investigation. Unfortunately such a discussion is beyond the scope of this chapter.
[342] See chapter four for extensive discussion of this device and its properties.
[343] A list of coordinates for different places in Japan is given in Inō's *Nihon kei ido jissoku* 日本経緯度実測 (*Measurements of Longitudes and Latitudes of Japan*) 寛政十二, 1800. Tōhoku University, Kano Archive.
[344] Inō Tadataka Memorial Museum in Sawara city.
[345] Ōmi Jingu Shrine holds one functional pendulum clock. The Kojū Bunko Archive holds non-functional pendulum clock used in Kaga domain. Another pendulum clock is preserved in the Tokyo National Science Museum in Ueno.
[346] In 1800 Yoshitoki wrote in reply to a query whether it was possible to make observations without a pendulum clock. In a very detailed and polite reply Yoshitoki suggests that the pendulum clock is usually the best method for making observations, and while in some cases it is possible to use other methods, in others the clock is indispensible. Then, Yoshitoki proceeded to explain the use of the clock and the calculations associated with it. Hisashi Uehara et al ed., *Tenmon rekigaku shoka shokanshū* (Collection of Various Astronomers' Correspondence) (Tokyo: Kodansha, 1981), pp. 68-74.

The specific pendulum clock used by Inō counted on average 59,504 oscillations a day, with a daily variation of no more than two oscillations in ideal conditions.[348] As with other *Suspended Swinging Disk* devices, Inō's clocks counted oscillations in three dials and two small windows, and as was the case with other pendulum clocks, it was indispensible in Inō's observations.

Since Inō's mission was first of all driven by astronomical motivations, observations for determining the latitude and compiling new tables of stars' culminations[349] became an inseparable part of surveyors' daily routine: the expedition was surveying by day and making celestial observations by night, setting observation stations in the inns they stayed at. In the course of his eighteen-year long surveying career, Inō set up more than twelve hundred observation stations, in twenty of which the measurements were made in the course of several days. In each one of the stations, a pendulum clock was set, determining the local true noon and timing the celestial phenomena.

The correction of tables was especially important for Yoshitoki who felt that inaccuracies of the tables provided in the Chinese *Compendium of Observational Astronomy* were the reason behind his miscalculation of an eclipse several years prior to that. Yoshitoki himself worked on the compilation of new tables at the Astronomical Bureau in Edo, and Inō made his observation for the purpose of verification by comparison between the estimated times and the recorded ones. In this sense, the surveyors' routes were marked with observation points,

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[347] Famously described in Shibukawa Kagesuke 渋川景佑, *Kansei Rekisho* 寛政暦書 (*The Book of Kansei Calendar*), 安政六 (1859), reprinted in Asami Megumi, Yasuda Ken, ed., *Nihon kagaku gijuTsukōtenseki shiryō. Tenmongaku hen*. Vol. 2. Although references to time measurement are scattered throughout this thirty-five volume book, the specific description of the pendulum clock can be found on pp. 425-429, and pictorial representations are on pp. 371-375.

[348] Although, as we shall see later, most of the time the conditions were far from ideal.

[349] As a point of reference, it was decided not to use the tables provided in the Chinese *Lixiang kaocheng* 暦象考成 (Jap. Rekishō kōsei *Compendium of Observational Astronomy*), which Yoshitoki felt failed him.

which were both defined in terms of local time and linked by comparison to the observations made in Edo.

This conceptual link between observation stations and the center in Edo, was even stronger in the case of longitude observations. The idea of calculating the longitudinal value through pendulum clock measurements emerged almost spontaneously. In 1798 Hazama Shigetomi, happened to be back in Osaka when a meteor was seen in the skies of Japan. Needless to say, both he and Takahashi Yoshitoki observed the phenomena, making simultaneous measurements in Osaka and in Edo. The experience of simultaneous measurements brought about a sudden realization of which Shigetomi wrote to Yoshitoki: "Asada Ryūtatsu[350] mentioned that by making a simultaneous observations of a meteor in different places it might be possible to calculate the distance between them."[351] To which Yoshitoki replied that this is indeed so, and that in fact, not only meteors but also any kind of eclipse would produce a calculation of distance when simultaneously measured with the pendulum. A month after, he wrote to Shigetomi again, providing him with the calculations of the distance between Edo, Osaka and Kyoto he had arrived at through the comparison of observation times.[352] And this was exactly the method he instructed Inō to use in his trips.

The optimal comparison would be through an observation of an eclipse; but eclipses, even lunar, were quite rare, and there was a high risk that such observations would be disrupted by bad weather conditions.[353] Therefore, Inō was mostly observing the occultation of the satellites of Jupiter — a method that Yoshitoki probably found in one of the Chinese-language

[350] 麻田立達 (1771-1827) Eldest son of Shigetomi and Yoshitoki's teacher Asada Gōryū.
[351] Letters from Kansei 10 (1798), cited in full in Watanabe Toshio, *Kinsei nihon tenmongakushi*, p. 607-609.
[352] Letters from Kansei 10 (1798), cited in full in Watanabe Toshio, *Kinsei nihon tenmongakushi*, p. 607-609.
[353] Which indeed happen to Hazama Shigetomi, who traveled all the way to Kyushu to observe a total eclipse of the moon but failed to do so because of the weather.

Jesuit treatises.[354] Sometimes he compared his measurements to the tables prepared beforehand by Yoshitoki, and sometimes, simultaneous observations were made at the unknown location of the Inō party and at the observatory in Edo, to be compared later.

These observations, made to establish the correct position of the unknown point on the map, not only resulted in an accurate map, but also created a conceptual link, a link of time, between the unknown locality and the center. Not much was inscribed on the ground, in the course of the surveying, as in many cases longitude could be determined only following a posteriori comparison with observational data in Edo. Consequently, there was no map carried from the unknown lands to the center.[355] Yet even before the surveyors' measurements were physically laid down on a map, even before the archipelago came to be visually represented as organic geographic unity, the various regions traversed by the surveying expedition came to be conceptually unified as one continuous space linked together by the oscillation of pendulums.[356]

Inō's journey, though not without troubles and obstacles, proved to be successful in terms of its original goal: he managed to measure the distance between the 35° and 41° of latitude. Dividing the distance by the difference between the two latitudes he arrived at the measurement of 28.2 *ri*, or 110.85 km in modern day terms, which can be considered quite accurate compared to the modern value of 110.98 km. But in addition to determining the value of one meridian degree, Inō's expedition became famous for its surveying, and gradually developed into a grandiose, government sponsored mapping project of the whole of Japan. Government officials

[354] Watanabe, *Kansatsu Gijutsu*, p. 611.
[355] As was in the case described by Graham Burnett in *Masters of All they Surveyed*.
[356] Bruno Latour in "Drawing Things Together," attributes primacy to "inscriptions" of actual maps, in constituting social claims. (in M. Lynch and S. Woolgar eds., *Representation in Scientific Practice*. (Cambridge, MA: MIT Press, 1990), pp.19-68) My point here is to show that there is a long conceptual process *prior* to the actual inscription. This process is not necessarily singular, confined to one specific explorer, but rather rooted in a set of practices and communal conceptual development, even though that "community" might be very small at this point.

still could not grasp the importance of Inō's astronomical findings, which benefited only a handful of professional astronomers. However, they could not fail to notice the potential use of the highly detailed land survey, especially that of the previously under-surveyed northern island of Ezo, which was still considered to be semi-barbaric and in need of control.[357] In the following years Inō's surveying party set out on more and more expeditions, surveying coastlines, highways, mountains, and with each mission the government bestowed on him more and more privileges and bigger budgets. In the course of the next eighteen years, Inō's group made another ten major expeditions, and numerous local surveys, crisscrossing all the four islands of Japan and attaching the surveyed places to the latitudes and longitudes determined with the help of the pendulum clock.

Neither was Inō alone in his mapping aspirations. Passing through the Kaga domain, Inō taught the art of astronomical surveying to Ishiguro Nobuyoshi,[358] and indirectly influenced Endō Takanori,[359] whom we met in the previous chapter. Following Inō's visit in Kaga domain, a pendulum clock, the *Suspended Swinging Disk Device,* was made there for the purpose of surveying and time-keeping, and it is still preserved in the Shinminato City Museum.

Another student of Inō's played an even more crucial role in the history of Japanese geography. The student was Mamiya Rinzō,[360] who, although not especially talented for astronomical surveying, was nevertheless exceptionally ambitious. Mamiya accidently met Inō

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[357] Wonderfully described by David Howell in *Geographies of Identity in Nineteenth century Japan* (Berkley: University of California Press, 2005). There are also many Edo period sources depicting "barbaric" people of the northern island. Among them is *Illustrated Explanations of Northern Ezo* (*Kitaezo zusetsu* 北蝦夷図説), written in1807 (文化四) by explorers Mamiya Rinzō 間宮林蔵 and Murakami Teisuke 村上貞助.

[358]石黒信吉由 (1760-1836). Shinminato Museum ed., *Etchū no ijin Ishiguro Nobuyoshi* 越中の偉人石黒信由 (*The Great Man of Etchū: Ishiguro Nobuyoshi*) (Shinminato: Shinminato Museum, 2001), pp. 12-14.

[359] 遠藤高璟 (1784-1864). Onabe Tomoko 尾鍋智子, *Zettai tōmei no tankyū: Endō Takanori cho shahōshinjitsu no kekyū* 絶対透明の探求 : 遠藤高[ノリ]著『写法新術』の研究(*Absolutely Transparent Pursuit: The Study of Endō Takanori's "New Technique of Depiction"*) (Kyoto: Shibunkaku, 2006) p. 46.

[360] 間宮林蔵 (1775-1844).

during the latter's expedition to Ezo and learned some surveying techniques from him.[361] He then set on further explorations of Ezo island and later even went beyond that, sailing further north and finally establishing that the land known to the Japanese as Karafuto is the same as what Russians call 'Sakhalin' and that this land is in fact an island on its own, and that the body of water on its north was not a large river but rather a strait, meaning that Karafuto was not a peninsula but an island.[362]

Unlike Inō's expedition, however, Mamiya Rinzō's survey was not astronomical. From the diary of the Russian captain Vasiliy Golovnin, we learn that his knowledge of astronomical measurements was barely sufficient: Mamiya Rinzō had astronomical tables and knew how to determine latitude by the less accurate method of measuring the sun's altitude, yet regarding the question of longitude, he asked Golovnin to teach him the method of lunar distances in which longitude could be found by measuring distance[363] between the moon and a preselected celestial body, and then comparing it to a table that provided the distance between these two bodies as observable from a location with known longitude.[364] Moreover, astronomical observations similar to Inō's were simply impossible for a lone traveler making his way on a light boat. The sheer weight and the size of the clock alone made it hard to travel with, not to mention that pendulum clock was useless without an octant and a meridian device, which had to be operated

[361] Watanabe, *Kinsei nihon tenmongakushi*, 405.
[362] Similarly to Bruno Latour's La Perouse, Mamiya Rinzō's intentions were, if not imperialistic, then at least done in the interest of the government. Brett Walker gives an outstanding description of Mamiya Rinzō's travels and the political impact of the surveying of the "barbarian" north. Taking Latourian approach, Walker attributes this achievement almost solely to Mamiya Rinzō, claiming that he brought about a firmer control of the lands by "placing them on the grid of longitudes and latitudes." Yet Rinzō never made astronomical observations, and the results of his survey could only be placed on the grid of longitudes and latitudes after they were incorporated into Inō's maps, which did *not* originate in imperialistic motivations. See Brett Walker, "Mamiya Rinzō and the Japanese Exploration of Sakhalin Island: Cartography and Empire," in *Journal of Historical Geography*, Volume 33, Issue 2, April 2007, pp. 283-313.
[363] The distance is measured in degrees of an angle.
[364] Vasiliy Golovnin, *Zapiski Flota Kapitana Golovnina*, (Khabarovsk: Khabarovskoe knizhnoe izd-vo, 1972), p. 173.

simultaneously with the help of additional observers. Instead, Mamiya took the value of one meridian degree as determined by Inō and applied it to the distance he measured, thus arriving at an estimation of latitude. Nevertheless, he was the first Japanese to survey the land as far as Russia, and the results of his survey were later integrated into Inō's map of Japan.

What we see in the example of geographical exploration of Northern territories, is a kind of convergence of very different kinds of knowledge and distinct motivations. Inō's party was motivated by an astronomical problem and initially even struggled to receive government recognition of the project, yet they possessed astronomical knowledge, superior instrumentation and were capable of group effort, which proved to be essential for precise surveying. Mamiya Rinzō, on the other hand, served as a government agent that strived to cover as much land as possible for the sake of government control, yet his ambitions came at the expense of accurate surveying and producing meaningful observational data. Nevertheless, the distinct abilities and motivations of the two explorers converged in the final product.

The enterprise of projecting all the data acquired through terrestrial surveys and celestial measurements, namely the creation of the actual map, began only in 1818, when Inō was already 73 years of age, and it was far from completion when Inō Tadataka passed away in March 1819. Takahashi Yoshitoki, who taught Inō the art of astronomical surveying and the methods of map projection, was long dead by then, succumbing to a disease in 1804 at the age of forty. The task of creating a unified map, therefore, fell to Inō's grandson, Tadanori, and on Takahashi Kageyasu,[365] the son of Takahashi Yoshitoki who took his father's position at the Astronomical Bureau after Yoshitoki's death. Kageyasu also inherited his fathers astronomical and geographic concerns, and virtually became Inō's right-hand man throughout the years. Owing to his high-

[365] 高橋景保 (1785-1829).

ranking position as well as to his astronomical expertise, Kageyasu thus became the chief architect of the map of Japan.

The project was completed in 1821. The end result was a large map consisting of 214 sheets of regional maps, a middle-sized map of 8 sheets and a small map of the whole of Japan in 3 sheets. The large map from the island of Tanegashima, covering the south-west to the north of Ezo, was on the scale of 1:36,000, the middle-sized one was on the scale of 1:216,000, and the smallest was 1:432,000. It was not only the scale of these maps that proved to be innovative. Inō's maps presented a new genre: whereas previous maps were made with practical goals on the ground, such as infrastructure projects, taxation, delineating political boundaries or private properties, or even maps for tourists and pilgrims, Inō's maps were motivated by astronomical observations. Their reference points were not some kind of significant landmark on the earth, but rather a celestial phenomena observable from all the different points on the map.

The maps were set on a grid of latitudes and longitudes, which in itself was not new. However, the novelty of Inō's maps was that the longitudes and latitudes of the maps were not just borrowed from the Western maps but rather determined on the ground, by the surveyors. Namely it was not that the new map was imposed on the existing grid of longitudes and latitudes; rather, the grid was determined alongside with the map. More importantly, the central meridian was set to run through Kyoto – the traditional cultural capital of Japan. This was not obvious, since it was not Kyoto, but rather Edo that could be considered a *calculation center*[366] where all major observations, and the ones with which Inō compared his data were conducted.

[366] Bruno Latour defines *centres of calculation* as centers of activity to which collected information and materials flows back, and around which social networks of scientists revolve. Bruno Latour, *Science in Action* (Cambridge, MA.: Harvard University Press, 1987), especially chapter six "Centres of Calculation."

But Kyoto was considered to be the cultural heart of Japan and official calendars distributed to the whole of Japan were based on the local time in Kyoto. Consequently, the comparison of field data with fixed point of calculation center didn't empower the center of calculation itself, but rather a culturally significant and intentionally chosen point of reference. By arranging the map around the central meridian of Kyoto, all the distant regions on Japanese archipelago came to be tied to the center conceptually. Their location came to be seen as tied to Kyoto's longitude, and time measurement, essential to determination of the longitude, created one inseparable continuum—the Greater Japan.[367]

The new map represented a political entity that was defined not only by political contracts of various domains, but rather as an organic unity defined by observed celestial phenomena. The pendulum clock, essential to the observations, did not only produce measurements for more accurate surveying of the land, it transformed the very way space was perceived and viewed. The map was a consequence, a partially unintended result of the initial expedition that didn't necessarily have national aspirations. Yet the incorporation of timekeeping patterns into exploration of spaces served as a platform for the development of the idea of geographic and national unity.

The Siebold affair

Inspired by the geographic exploration of Japan that extended all the way to the northern frontier of Ezo and even beyond, Kageyasu became fascinated with the world outside of Japan. So far, the outside world served Japanese astronomers as a source of knowledge — sporadic,

[367] Dai Nippon 大日本. Marcia Yonemoto, *Mapping Early Modern Japan: Space, Place, and Culture in the Tokugawa Period, 1603-1868*, (Berkeley: University of California Press, 2003) makes an excellent case showing how travels, actual and imaginary, contributed to the creation of this notion of the unified entity of Japan. Here I want to stress the material (the clock) and the conceptual (space as time) aspects that contributed to the emergence of the notion of "Japan" as a unified entity.

incomplete, contradictory bits that came from Chinese translations of Jesuit treatises, which presented sometimes outdated practices and Tychonian cosmology, and also from Dutch translations of popular science books, such as John Blaeu's *Atlas*, which were translated into Japanese by Nagasaki interpreters.

We should note, however, the nature of these translations. The archetypal translation in the eighteenth century Japan was translation from Chinese into Japanese, and in many cases it involved rearranging Chinese characters in a different order and adding a Japanese-language markings for grammar. Translating from Chinese, Japanese scholars had to interpret series of ambiguities in Chinese sentences, but they hardly had to struggle to interpret the characters, which were left as they were. Most of Chinese terms were already culturally meaningful in Japanese, while the philosophically complicated ones simply invited whole treatises on their interpretation. This model could hardly work for translations from Dutch, where not only the script, the vocabulary and the grammar were completely different, but also the concepts reflected by the words were completely new. Take for example the reaction of Sugita Genpaku,[368] the famous physician whose *New Book of Anatomy*[369] is said to be a translation of Adam Kulmus' *Anatomische Taffellen*, and thus constituted the first scholarly translation of an anatomical text:

> Then we faced the book. But it was as though we were on a boat with no oar or rudder adrift on the great ocean – a vast expanse and nothing to indicate our course. We just gazed at each other in blank dismay.[370]

Japanese interpreters were definitely aware of both the difficulties they encountered with the Dutch language and of their own shortcomings. Some made a clear distinction between "Japanese interpretation" and "explanations" where the latter was purely based on the

[368]杉田玄白(1733-1817).
[369] *Kaitai Shinsho* 解体新書, first version of which saw light in 1774.
[370] Sugita Genpaku, *Dawn of Western Science in Japan. Rangaku Kotohajime*, Tomio Ogata, trans., (Tokyo: Hokuseido Press, 1969), pp. 33-34.

interpreters' own thoughts.[371] The authors of *New Book of Anatomy* admitted that even though they considered their work to be a "translation",[372] only some of the words were translated literally,[373] while others were either neologisms[374] or just transcriptions[375] of the Dutch sounds.[376] "Translation" therefore, could also mean a dozen of pages of author's own thoughts about what might be written in the 500-pages long Western book, accompanied by Japanese transcription of titles, names of people, countries, heavenly bodies and others.[377]

But the most difficult part was, of course, grasping the implication of Dutch words on the fields of medicine, natural history, astronomy and navigation. Translating unfamiliar scientific notions involved understanding them first, which was impossible for somebody with no serious background in these fields. As one of the most accomplished eighteenth century scholars of Dutch language, Ōtsuki Gentaku[378] claimed, "translation" was necessarily based on the previous knowledge of the field:

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[371] In the prefece to *Oranda kinjūchūgyozuwage* 阿蘭陀禽獣虫魚図和解 (*Japanese Interpretation of Dutch Pictures of Birds, Beasts, Reptiles and Fish*), Norō Genjō (野呂元丈 1693-1761) distinguished between *wage* 和解 and *setsu* 説. See Yōzaburō Shirahata, "The Development of Japanese Botanical Interest and Dodonaeus' Role: From Pharmacopoeia to Botany and Horticulture" in *Dodonaeus in Japan : Translation and the Scientific Mind in the Tokugawa Period*, eds., Willy vande Walle and Kazuhiko Kasaya (Leuven; Kyoto: Leuven University Press; International Research Center for Japanese Studies, 2001), pp. 267-268.

[372] *Yaku* 訳.

[373] *Honyaku* 翻訳.

[374] *Giyaku* 儀訳.

[375] *Chokuyaku* 直訳.

[376] Vande Walle, "Linguistics and Translation in Pre-Modern Japan and China," in W.F. Vande Walle and Kazuhiko Kasaya, eds., *Dodonaeus in Japan: Translation and the Scientific Mind in the Tokugawa Period* (Leuven : Leuven University Press, 2001), pp. 133-135.

[377] As it was the case with Norō Genjō's *Oranda kinjūchūgyozuwage* (*Japanese Interpretation of Dutch Pictures of Birds, Beasts, Reptiles and Fish*).

[378] 大槻玄沢 (1757-1827).

> There are differences in the ways of reasoning and the methods of Chinese and Western [science], but when it concerns the same area of specialization, we are able to infer, and things are therefore easy to understand, and we quickly acquire an insight in that matter.[379]

The unavoidable side effect was that texts, which were labeled as translations from the Dutch, contained concepts rooted in notions of yin and yang or *qi*. In order to make a significant contribution to the understanding of medicine, astronomy, natural history, navigation, etc., translators had to be well versed in the field they were translating, which was not necessarily true before the eighteen thirties and forties.

Professionals were aware of the amateur nature of these translations and often looked down on the interpreters' work. Criticizing Motoki Ryōei's translation of George Adams' *Treatise Describing The Construction And Explaining The Use Of New Celestial And Terrestrial Globes*, Hazama Shigetomi noted that "Motoki is ignorant in astronomy. Sometimes he translates based on his crude knowledge of astronomical names and numbers, and sometimes leaves the Dutch words as is"[380] and then proceeds to take apart every piece of numerical data in the latter's book. It was only around the year 1800 that Yoshitoki acquired a Dutch translation of Lalande's *Astronomie* — a theoretically innovative and technically sound astronomical treatise, which he attempted to translate with the help of several Japanese interpreters. Yoshitoki's death in 1804 was, of course, an obvious hindrance to this endeavor, although Takahashi Kageyasu did his very best to continue his father's project.

These popular books, impractical as they were, played however a crucial role in igniting the imagination and arousing a deep interest in the West and in the whole world in general. With

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[379] Ōtsuki Gentaku, *Rangaku kaitei* 蘭学階梯 (*A Stepping-stone to Dutch Studies*) 天明三 (1783), cited in Numata, *Western Learning: A Short History of the Study of Western Science in Early Modern Japan* (Tokyo: Japan-Netherlands Institute, 1992), p. 78.

[380] Hazama Shigetomi 間重富, *Tenchi nikyūyōhō kihyōsetsu* 天地二球用法記評説 (*Criticism of "the Use Of Celestial And Terrestrial Globe*) 寛政十 (1798), Gakushiin Archive.

these new interests, the domestic geographical explorations and a new vision of land as a continuous space unified by the celestial phenomena and described in terms of progression of time could not have stopped with the marine barrier that defined the Japanese archipelago. In the years of so-called isolation policy, Japanese scholars were, of course, prevented from traveling and exploring the subject of their inquiry directly. Yet this practical obstacle did not prevent them from making an imagined exploration of the world based on second-hand reports and their newly acquired perception of geography. The knowledge Mamiya Rinzō obtained in Sakhalin added to the reports of Japanese castaways who spent time in Russia[381] and of prominent Russians such as Laxman, Rezanov and Golovnin. Attempting to create a coherent picture out of the sporadic bits of available information, Takahashi Kageyasu too became involved in the numerous mapping projects that would enable him to place the separate pieces of a puzzle on a visually contingent map.[382] He further strove to explore the northern territories, was involved in the reproduction of an annotated map of the 'Russian New Capital of St. Petersburg,'[383] and worked on detailed world maps.[384]

Given these interests, it is not surprising that Kageyasu deliberately attempted to meet foreigners, especially those who possessed at least some degree of academic knowledge. He was especially thrilled to meet young Phillip Franz von Siebold — a young physician at the VOC factory on the artificial island of Dejima, which was built especially to accommodate the Dutch merchants. Siebold did not just happen to be there — the native German naturalist intentionally

[381] Such as Nakagawa Goroji, who was actually abducted by a Russian ship and spent several years on the continent. By his return however, he helped in spreading the new vaccination method he learned in the Russian village.
[382] That is, in addition to his extensive study of the Manchu language, as well as of Russian customs.
[383] *Rōshia shinto peteruburugu no zu* 魯西亜新都ペテルブルグ之図, Osaka Historical Museum, Hazama Archive .
[384] *Shintei Bankoku zenzu* 新訂万国全図 (*New Map of the Myriad Countries*), Waseda Online Collection of Chinese and Japanese Classics (http://archive.wul.waseda.ac.jp/kosho/ru11/ru11_00786/ru11_00786.html last accessed April 2012); and *Shinsen sōkai zenzu* 新鐫総界全図 (*New Map of the Entire World*), Waseda Online Collection of Chinese and Japanese Classics (http://archive.wul.waseda.ac.jp/kosho/bunko08/bunko08_c0994/bunko08_c0994.html last accessed April 2012).

sought employment by the VOC to get to Japan in order to explore the peculiar flora and fauna of the Japanese archipelago. He was quite successful in this mission – he arrived in Japan in 1823, and soon obtained permission to travel outside of Dejima, building a school of Western medicine on the outskirts of Nagasaki. On his annual trips to the capital he had extensive audiences with local scholars, and Takahashi Kageyasu was one of his frequent visitors. The two men shared a desire for knowledge: for Siebold it was knowledge about Japanese flora and fauna, as well as the country's costumes and history; for Kageyasu it was the knowledge of astronomy but also any possible information about the world outside of Japan. It is, of course, impossible to know the exact content of the communication between the two, yet we do know that they exchanged books, specimens and other objects of interest.

The new interest in space and geography was not, however, limited to a small group of scholars. The government, which initially was skeptical of Inō's expedition, gradually came to see the mapping mission as a matter of territorial importance. It jealously held on to the fruits of surveying project, restricting the use of Inō maps to the shogunal castle alone, actively shaping the quest for conceptualization of the land, both local and foreign. Already at the time of Mamiya Rinzō's expedition to the north the relations between him and the rest of explorers started deteriorating, and soon after, rumors started spreading that Mamiya was not only motivated by the desire to explore distant lands but also by his job as a secret government agent. From Golovnin's diary we learn that although Mamiya met with the Russians under the pretence of science studies, the meeting resulted in Mamiya's lengthy intelligence reports about the Russians and their alleged political intentions.[385] Yet Mamiya still had many connections in the scholarly world that allowed him to learn about Kageyasu's communication with Siebold, which he

[385] These reports were later presented as accusations against the Russians. Golovnin, *Zapiski Kapitana Golovnina*, p. 180.

promptly reported to his superiors in the secret police.[386] It seemed that Kageyasu's high-ranking position, and Siebold's international status would grant them both at least relative protection. However, a cruel twist of fate drastically changed the history of Japanese geography, and the history of nineteenth century Japanese science as a whole.

In September 1828 Siebold was preparing for what he though would be a temporary leave to Europe. The voyage was about to begin and Siebold's belongings were already loaded up on the ship, *Cornelius Houtman*, when a powerful typhoon hit southern Japan. On the night of September 18th, the typhoon destroyed many residences at Dejima and caused the *Cornelius Houtman* to loose its anchor and wreck on the nearby coast. After the typhoon passed, the local government sent a rescue mission to save the ship, but also used this as an opportunity to inspect the Dutch cargo. Among Siebold's personal belonging Japanese inspectors found detailed copies of Inō's maps. [387]

There was no need for a complicated investigation to discover who was the person who handed over the copies of the maps to Siebold— the only source could have been Takahashi Kageyasu, who was already under suspicion. Kageyasu was immediately imprisoned under accusation of treason and died several months after, while awaiting his sentence. His death did not stop the trial and the court ordered Kageyasu's dead body to be preserved in salt until the decision was made—a death sentence. Kageyasu's dead body was publicly executed and his family was exiled to a distant island. But the event also sent ripples across the Japanese scholarly world — Kageyasu's younger brother, Shibukawa Kagesuke, who was a high ranking astronomer on his own, had to virtually disappear from the intellectual scene for several years.

[386] Watanabe, *Kansatsu Gijutsu*, p. 406.
[387] Uehara Hisashi 上原久, *Takahashi Kageyasu no kenkyū* 高橋景保の研究 (*The Study of Takahashi Kageyasu*) (Tokyo: Kōdansha,1977), pp. 314-368

Siebold's medical students too were persecuted, [388] and for a while, the very attempt to deal with Western science was treated as a borderline treason. The aftermath of the affair didn't spare Mamiya Rinzō either— he was boycotted by all members of the intellectual community he knew before, and spent the rest of his life in a virtual isolation.

Siebold himself was put under house arrest immediately after the discovery of the maps and humiliatingly banished from Japan several months after. He left behind a wife and a daughter,[389] and was only able to come back in 1859 after the official opening of Japan to foreign visitors. Nevertheless, Siebold did bring back to Europe many notes, specimens, students' reports, and several copies of Inō's maps, which he managed to hide, aware of the delicate nature of such documents. After his return to Europe, he published a series of bestsellers — the *Fauna Japonica*, the *Flora Japonica* and his opus magnum, the *Nippon*, which incorporated his personal diary into a general description of Japanese people, their customs and their history. In the pictorial addendum to the book, Siebold included the maps of Japan, which he attributed to Takahashi Kageyasu.[390]

The publication of the map was an important event in European cartography. The exact shape of the Japanese coastline was not entirely clear yet, and the harsh northern area of Ezo and Sakhalin was a complete mystery. Neither the shape nor the position of the island of Ezo was known, and it was not even finally determined whether it was an island or if it was connected to Sakhalin. Moreover, it wasn't even known for sure whether Sakhalin itself was an island or

[388] See, for example, Ellen Gardner Nakamura, *Practical Pursuits: Takano Chōei, Takahashi Keisaku, and Western Medicine in Nineteenth-century Japan* (Cambridge, MA: Harvard University Press, 2005).
[389] Ine イネ, who became a doctor on her own.
[390] The map actually says "Takahashi Sukezaemon," which was Kageyasu's real name. "Kageyasu" was a pseudonym, which means "Shadow Keeper," referring to the shadow of the gnomon that historically was considered to be symbolic for astronomy. In the same manner, his brother Kagesuke's pseudonym means "Shadow's Assistant;" his father Yoshitoki's name means "Reaching Time;" Endō Takanori's pseudonym means "Tall Sunrays of The Dawn," etc.

perhaps it all formed one long land bridge that started just across the strait from the main island of Japan and stretching all the way to eastern Russian territory. Several Europeans tried to determine the shape and the positions of the island before — the French François La Perouse tried to do so in 1787, the English William Robert Broughton made his attempt in 1796-1797; in 1804 the Russian Adam Krusenstern surveyed the Western coast of Japan naming the sea that he sailed "The Japan Sea," and his compatriot Vasiliy Golovnin was on a surveying mission when he was captured by the Japanese authorities in 1811. These attempts, however, were all made from ships, at a distance from the shore, thus making their measurements less accurate, compared to today's values. Moreover, each one of these surveyors made only partial measurements, covering only a specific areas of the puzzle. The map given to Siebold by Takahashi Kageyasu, on the other hand, provided one unified view of a continuous space, combined with the detailed outline of the coastline and precise measurements of the longitudes and latitudes. Adam Krusenstern (who discounted Japanese scientific knowledge in 1804[391]) came to praise the "progress Japanese sciences made" in the precision of both details of coastal survey and the longitude and latitude measurements.[392]

Siebold, however, did not publish Kageyasu's maps as is. Rather, he added the coordinates acquired in the European surveys on top of the Japanese measurements, and mentioned place names bestowed by the foreigners alongside the Japanese and the local, Ainu ones. Japanese authorities perhaps used surveying, measurements and maps in order to gain better control of the Western territories, but through the addition of Western coordinates and names Siebold virtually committed the very act Japanese government feared the most — he subordinated these territories to Western parameters. Moreover, when indicating the longitude,

[391] See the next section on navigation.
[392] In a letter to Siebold. Cited in full in original German in Otani, *Tadataka Inō*, p. 150

he mentioned the Japanese value that took the location of Kyoto as the reference point, but put it alongside with the Western, Greenwich oriented longitude. With this addition, Siebold conceptually displaced the centrality of Japan, and confined the Japanese time that stood in the basis of longitude measurement to isolation. If previously, Inō's map represented a temporal continuum anchored in the culturally significant local time of Japan's ancient capital, Siebold's new map subordinated Japanese space to a continuum of a global flow of time and placed it on the periphery, far away from the temporal center. [393]

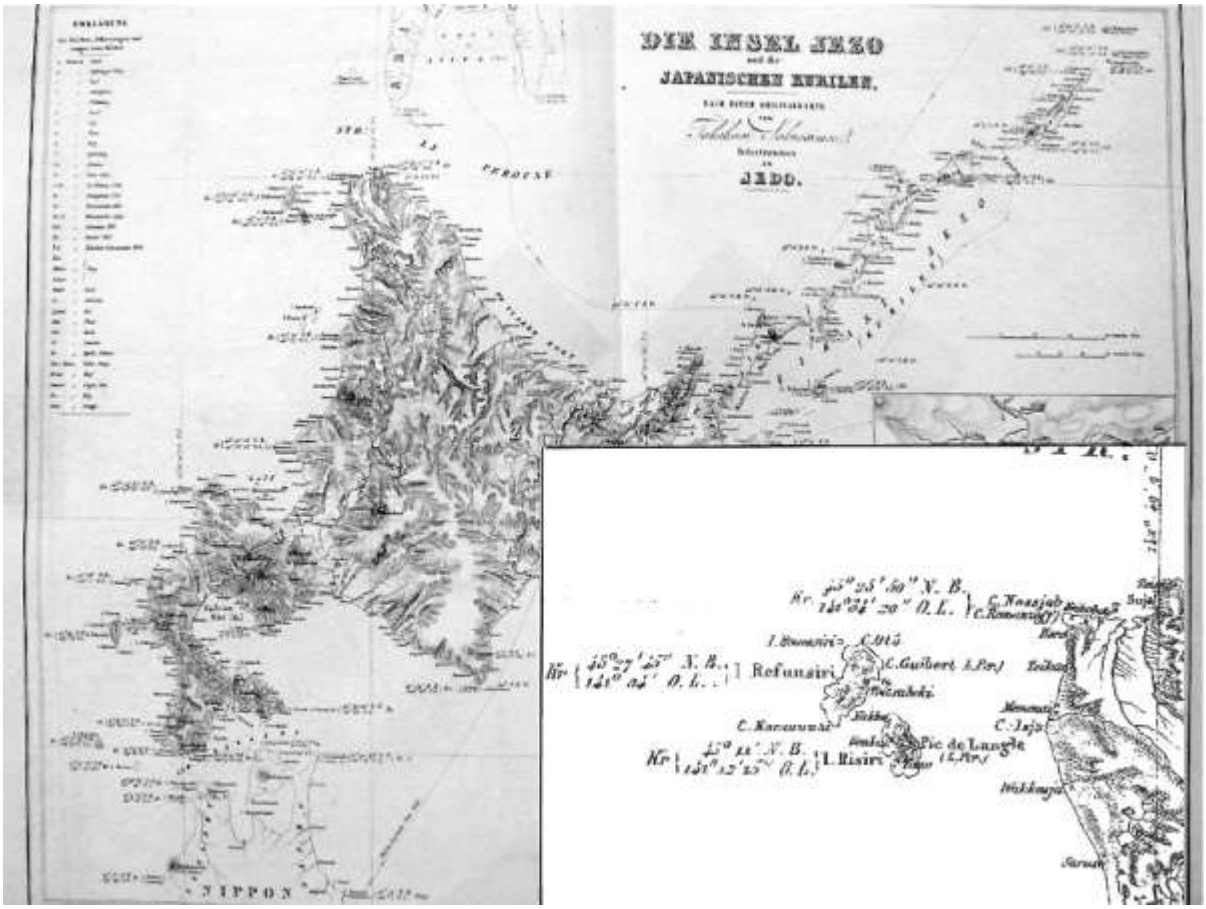

Image 11. Siebold, *Nippon*. Princeton University Rare Books Collection.

[393] The political importance of the temporal center that defined geographical continuum is well seen in the mid-19th century disputes concerning the placement of the prime meridian. See Peter Galison, *Einstein's Clocks and Poincaré's Maps*: *Empires of Time* (London: W.W. Norton, 2003).

A map of “The Island of Jezo and the Japanese Kurils”, attributed to Takahashi Sukezaemon (Kageyasu was a public pseudonym). On the upper left we see a list of all the people, Japanese and Westerners alike, whose measurements are mentioned in the map. In the bottom right you can see an enlarged northern tip of the island with coordinates measured by Krusenstern and La Perouse’s place names (such as *Pic de Langle*), alongside with Japanese ones.

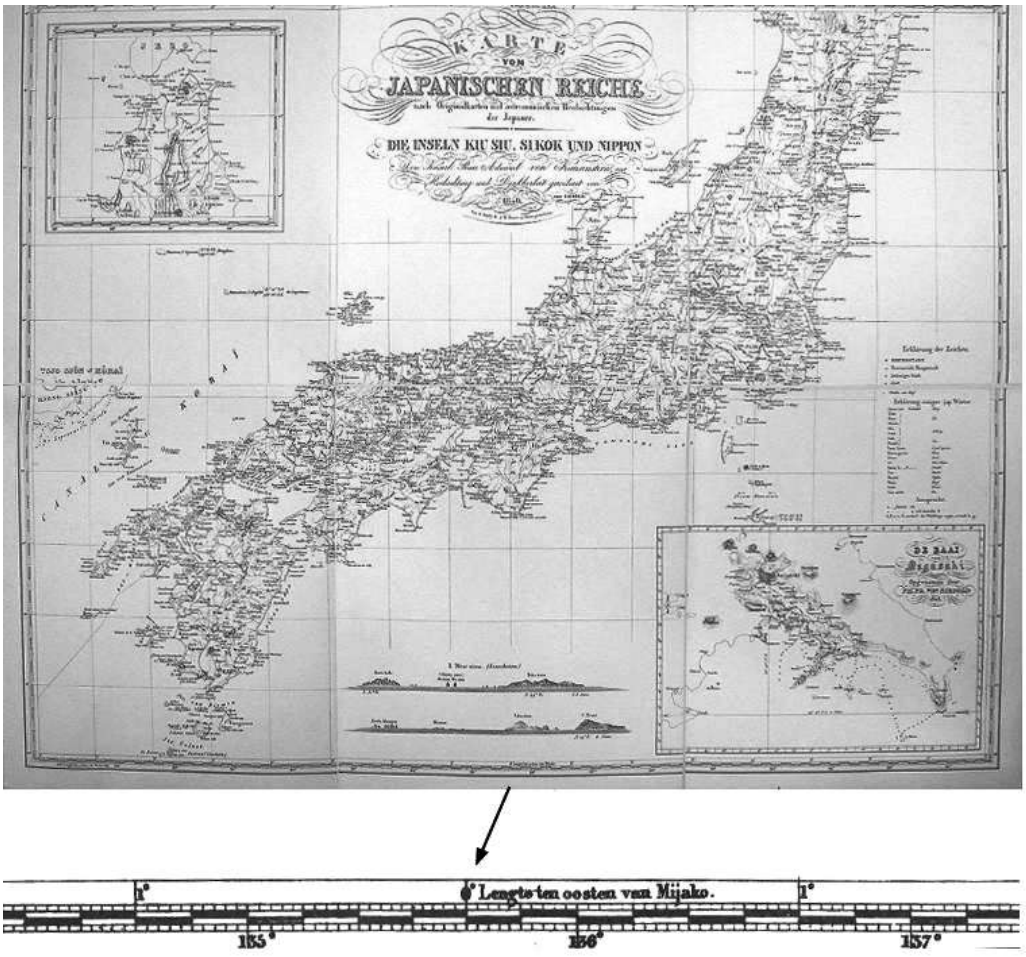

Image 12. Siebold, *Nippon*. “The Map of Japanese States” based on Inō Tadataka’s map of Japan.

The enlarged section on the bottom shows the two longitudinal scales — the Kyoto (“Mijako”) based one, and a Greenwich one.

Navigation

Although it might seem that Siebold was inadvertently stealing Japanese time, he did, in fact, make a major contribution to the development of the concept of a different kind of time—a global, and objective time independent of human activity, the time of a marine chronometer. The invention of a marine chronometer in the West is often described as being motivated by a very real and practical problem— the loss of ships and their cargo due to inability to correctly calculate their positions.[394] In Japan, however, no such practical consideration could be found: Japanese ships that carried goods circled the island in the relative proximity to the shore, while actual open sea sailing was not an option, because of the restrictions on traveling abroad imposed by the Tokugawa regime. Nevertheless, the lack of practical motivation, or even real experience in sailing, didn't prevent Japanese scholars from developing similar aspirations to those of their Western counterparts. They did so neither by developing identical practices nor by accepting a novel and complete theory from the West. Rather, by linking the bits of sporadic information about Western astronomical practices, and following the logic of astronomical time-measurement, they were able to reconstruct a notion of time embedded in Western invention.

As we have seen in the first half of this chapter, the measurements of the pendulum clock facilitated an emergence of a notion of space that was defined by time and bound by time to a specific cultural center. Yet at the same time, as already mentioned before, these exact measurements also raised interests in the lands outside of Japan and, with the extraordinary exception of Mamiya Rinzō's intrusion into Russian territory, were beyond the reach of any Japanese. But Japanese scholars were still inspired to sketch maps of foreign lands and were

[394] See William Andrews ed., *The Quest for Longitude* (Cambridge, MA.: Collection of Historical Scientific Instruments, Harvard University, 1996).

contemplating the possible sea voyage—a voyage that would require one to determine the position and the route of the ship. As we will see, it was in these imagined travels that the idea of independent time was conceived, and eventually solidified by the marine chronometer and its measurements.

An exceptionally prolific polymath, Honda Toshiaki, [395] was among the first to outline the vision of open-sea navigation in 1804, in his *New Method of Crossing the Sea*.[396] Widely known for his writings about political economy, [397] Toshiaki was also enthusiastic about Western science and saw Europe as a kind of moral and scientific utopia of creativity and efficiency.[398] The two interests were not unconnected — Toshiaki propagated adopting both Western science and (what he thought to be) the Western way of government in order to improve the economic and hence the moral situation of Japan. For this reason he advocated lifting the ban on traveling abroad and colonizing not only Ezo but also Kamchatka in order to exploit the natural resources of these places. Most importantly for our purpose here, was what Annik Horiuchi called his "geographic determinism."[399] Similar to European thinkers of the Enlightenment, such as Montesquieu,[400] Toshiaki insisted there must be a correlation between a country's climate and the mode of its government. For this purpose, he claimed that it was essential to determine the

[395]本多利明 (1743-1821).
[396] Honda Toshiaki 本多利明, *Tokai shinpō* 渡海新法, 享和二 (1802) reprinted in Sumida Shōichi 住田正一, ed. *Kaiji shiryō sōsho* 海事史料叢書 (*Collection of Maritime-related Sources*) (Tokyo: Ganshōdō Shoten, 1929-1931) vol. 6, pp. 221-277.
[397] Especially noteworthy is *Keisei hisaku* 経世秘策 (*A Secret Plan of State Craft*), written in the Kansei period (i.e., between 1789 and 1800).
[398] Annick Horiuchi, "Honda Toshiaki (1743-1820) ou l'Occident comme utopie," in F. Girard, A. Horiuchi, M. Macé (dir. & éd.), *Repenser l'ordre, repenser l'héritage: Paysage intellectuel du Japon (XVIIe -XIXe siècles)* (Droz, 2002), pp. 411-448.
[399] *déterminisme géographique*. Horiuchi, "Honda Toshiaki (1743-1820) ou l'Occident comme utopie," p. 425.
[400] See Montesquieu's *Persian Letters* and *The Spirit of the Laws*.

exact location of each country, in order to learn about their climate and deduce from it their political potential.[401]

It was these particular interests that motivated Toshiaki to contemplate potential open-sea navigation. He claimed that he read the Western literature that was available to him, and that was comprised of popular Dutch navigation atlases and the Chinese *The Instruments Used in Observatory*, the latter of which did not deal with navigation at all, but rather explained the instruments used in the Imperial Observatory in Beijing. He even tried to sail on the boats that circled around Japan, to gain insight into the sailing experience. Yet he obviously never sailed into the open sea, so that most of his writing is a pure theoretical speculation.[402]

Toshiaki was obviously aware of the very different nature of coastal sailing and the open sea sailing, explicitly creating two different terms to refer to those.[403] In his attempts to learn the profession by sailing on the merchant ships he learned that navigation was done by personal knowledge of the sea bedrock and orientation on visible landmarks on the shore. In the latter case, however, no landmarks were available and the navigation had to be done with astronomical calculations, estimating the course and calculating longitude and latitude. For the calculation of longitude he proposes the following method:

> At a determined day, starting from noon exactly, prepare the clock. Then, that night, wait until a certain big star reaches the foremost south. Then take the time that passed since that noon to this point and verify it with the measuring clock. This would be the time for this star. In the tables, estimate what should be the time of this star being in the south at this specific day at the country of origin, and register that time. Compare the measured time with the estimated one, and find the time difference between the

[401] *Seiiki monogatari* 西域物語 (*Tales of the West*), 寛政十 (1798). Reprinted in *Nihon Shisō Taikei*, vol. 44 (Tokyo: Iwanami Shoten, 1970), pp. 87-162.

[402] Iida Yoshirō 飯田芳郎, *Tokai shinpō ni okeru kōkaigaku* 渡海新法における航海学 (Navigation of 'New Method of Crossing the Sea'), in *Kaijishi kenkyū* 海事史研究 *(Journal of the Maritime History)*, vol. 28 (1977), pp. 1-25.

[403] *Chijō* 地乗 and *chūjō* 沖乗.

> country of origin and the time of the place where the ship is. If the measured time is less than estimated, the ship is to the West of the origin; if it is more, then the ship is to the East of the origin. Take the time difference, multiply it by 15 and you will get the difference in degrees and hence in the longitude. If the ship is to the east of the country of origin, then the longitude would be eastwards; if it is on the West, then the longitude would be to the West.[404]

This method was obviously inspired by the astronomical observations of Takahashi Yoshitoki and Inō Tadataka made with their pendulum clock. However, Toshiaki had to modify the methods for several reasons. First of all, the pendulum clock used by astronomers could not be used for the calculations made at sea. There was no need to take the pendulum clock into the open sea, or even to sail with it at all, in order to find out that it would stop with any trembling of the ship. Therefore, Toshiaki writes that for the use on the ship it is not good to have pendulums, and suggests using a spring driven device instead. The clock that he suggested to use was a "second-clock" that measured 86,400 seconds in one day. Namely, Toshiaki suggested using a Western pocket-watch that has a second hand— an object already seen in Japanese markets by that time.[405]

But there was another concern that caused Toshiaki to deviate from the methods of his friends, the astronomers: eclipses observed by Yoshitoki were not suitable as an object of observation since they occurred rarely and demanded a later comparison with the observations made at the point of origin for the final determination of the longitude. And although versed enough in astronomy to know that longitude is measured in time, Toshiaki was probably not aware of Inō's observation of the satellites of Jupiter, the timing of which could be predicted and written down in a table, as he choose instead to focus on a random star. This choice is not entirely groundless, since in the determination of latitude any star can give one the required

[404] *Tokai shinpō*, in Sumida Shōichi, ed., *Kaiji shiryō sōsho*, Vol. 6. pp. 263-265.
[405] *Tokai shinpō*, in Sumida Shōichi, ed., *Kaiji shiryō sōsho*, Vol. 6, p. 235.

measurement. However Toshiaki's method could not have produced the desired longitude, since the time he measured was an apparent time,[406] while the moment when a star was at its southernmost position was in sidereal time.[407] Consequently, Toshiaki couldn't have arrived at the longitude measurement no matter what kind of timepiece he would use to make the calculation.

Here is where Siebold's chronometer became crucially important. First of all, the chronometer provided a better solution to the measuring of time amidst a trembling sea than the pendulum clock, but it also served as a material embodiment of another kind of time — an absolute, mean time.[408] The first one to use a chronometer on the Japanese soil was actually not Siebold but Adam Johann von Krusenstern.[409] Frustrated with his confinement to Megasaki during his visit to Japan in 1804-1805, Krusenstern amused himself by measuring the longitude and making astronomical observations. In an intriguing coincidence, on the very day he was disappointed by the cloudy skies that prevented him from seeing a total eclipse of the moon, Japanese astronomer Hazama Shigetomi was just several miles away, and equally disappointed with the impossible conditions to observe the eclipse, for which he traveled all the way from Osaka. Yet judging by Krusenstern's description of the Japanese people as "having no notion of geographical longitude or latitude," and his statement that "in a town of not great distance from Jeddo,[410] [there are] people who inhabit the temple and called *Issis*, and who possess the art of

[406] Defined by the interval between sun's crossing of the local meridian and its return to the meridian on the next day.
[407] Time that takes a particular star to return to its position relatively to the earth. A sidereal day is roughly 23 hours and 56 seconds in our terms.
[408] Because earth's rotation around the sun is not uniform, the time that takes the sun to return to the meridian (i.e. one day according to the apparent solar time) differs throughout the year. Mean time is the average time of these variations.
[409] Aka Ivan Fyodorovich Kruzenshtern (1770-1846).
[410] Edo.

foretelling eclipses of the sun and the moon,"[411] we can conclude that not only did he fail to meet Hazama Shigetomi, but he never met any Japanese professional astronomer at all, and hence could not demonstrate to them the chronometer and its use.

Unlike Krusenstern, Siebold's use of chronometers was open for all, as he came to Japan well-equipped, and on his trip to Edo, 'besides a barometer and Torricellian glass tube for altitude measurement, hygrometer and thermometer, [he] carried a chronometer of Hatton & Harrig, London, a sextant also made in London, supplied with a nonius from which one could read 15 seconds; artistic horizon and compasses, etc., as well as electric and galvanic apparatuses, several compound microscopes, and finally, a small fortepiano, with the aim that the Japanese would learn and cling to the European arts and sciences and eventually be able to produce those.'[412] Siebold makes it quite clear that most of the instruments were brought to create a spectacle, yet the chronometer was one of the few he actually put into use, measuring the longitude at least five times during his trip.[413] Some of these measurements too, were made as a mode of entertainment for his various royal hosts, but, as mentioned before, they didn't fail to catch the attention of the scholars, Takahashi Kageyasu among them. Siebold even promised Kageyasu to send him a chronometer, although obviously, this plan was never realized due to the scandal and the subsequent death of Kageyasu.

Nonetheless, immediately after Siebold's introduction of the chronometer it became a standard part of local astronomical practice, gradually replacing the *Suspended Swinging Disk*

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[411] Ivan Fedorovich Kruzenshtern, *Voyage around the world in the years 1803, 1804, 1805, & 1806 ... on board the ships Nadeshda and Neva under the command of Captain A.J. von Krusenstern*. Volume 1. (London : Printed by C. Roworth for J. Murray, 1813), pp. 279-280. I am not sure what the name *"Issis"* is supposed to stand for.

[412] Philipp Franz von Siebold, *Nippon, Archiv zur Beschreibung von Japan; vollständiger Neudruck der Urausgabe zur Erinnerung an Philipp Franz von Siebold erstes Wirken in Japan, 1823-1830, in zwei Text-und zwei Tafelbänden, dazu ein neuer Ergänzungs- und Index-Band von Dr. F.M. Trautz* (Berlin: E. Wasmuth, 1930-31), p. 53.

[413] On February 16th, 24th, March 5th, 7th, and April 14th. Philip Franz von Siebold, Nippon, *Archiv zur Beschreibung von Japan*, pp. 79, 112, 133, 139, 187.

pendulum clock. As we have already seen, although the fact that the pendulum clock was prone to the influence of the weather was known already to Yoshitoki and Shigetomi, they did not have any better alternative. The situation changed with the beginning of the import of precision watches from Europe, that counted not only hours and minutes but also seconds – units as small as 1/86400 of a day. Once the chronometer became available, the disadvantages of the pendulum clocks stood out. Thus, for example, in his *Account of Divine Constitution*,[414] Shibukawa Kagesuke stated that "already Hazama Shigetomi and Takahashi Yoshitoki noted that when candles are extensively used in the proximity of the *Suspended Swinging Disk Device*, or, when many people gathered around, the sequence of swings would be lost. Or, the same is when the weather is extremely cold."[415]

The solution of the older generation to this problem was "to confirm the number of swings with the total number of swings in one cycle, and when using it would be pretty much precise." [416] Seeing, however, that in addition to the fact that "according to the variations in the heat and cold of that day, the daily number of the swings can slightly differ from 3-4, to 5-7 swings", it was also "impossible to install a pendulum clock on the ship for the purposes of navigation," Kagesuke decided to solve all the troubles with the pendulum clock by following the Western navigational practices and use "the *Three-indexed Time Machine*."[417] It was surprising for Kagesuke that although "the construction [of the device] is the most precise and it would be perfect for observations, [in the West] it is not applied to the rotation of the

[414] Shibukawa Kagesuke 渋川景佑, *Reigen kōbo* 霊憲候簿, entries from 1797 to 1846. NAOJ archive.
[415] Cited in Watanabe, *Nihon kinsei tenmongakushi*, p. 564.
[416] Cited in Watanabe, *Nihon kinsei tenmongakushi*, p. 564.
[417] Shibukawa Kagesuke 渋川景佑, *Shōchū jishingi jimō* 掌中時辰儀示蒙 (Pointing out the ignorance about pocket watches), Tokyo University Archive.

heavens."[418] He himself, nevertheless, decided that if chronometer is the best-suited instrument for navigation, it could be perfectly used for the *similar kind* of astronomical observations on the steady ground.

The chronometers were not flawless — in 1842, a Confucian scholar and a clock collector Satō Issai noted that he had to lend one chronometer to Kageyasu's younger brother, Shibukawa Kagesuke, because the latter's chronometer broke and he urgently needed one to observe a lunar eclipse.[419] Yet the idea that chronometers were more suitable for astronomical observation took root, and astronomers came to measure time exclusively by the means of chronometer. This practical change produced another transformation in astronomical time in just several decades. At the end of the eighteenth century, with the birth of the Japanese pendulum clock, astronomical calculations went through a metamorphosis from 10,000 equal daily decimal units to an undetermined number of roughly 60,000 oscillations a day. In 1830s and 1840s astronomical calculations no longer took the oscillation of the pendulum as their reference; rather the calculations came to be based on the Western system of 24 hours, 60 minutes and 60 seconds, 86,400 seconds altogether.

Yet it was not only the amount of units measured per day that changed here, for the chronometer's was an entirely different kind of time. Already in 1802, Yoshitoki wrote notes concerning his reading of English Nautical Almanac from 1795, where he first encountered the

[418] Watanabe, *Kansatsu Gijutsu*, p. 567.
[419] Satō Issai diary from 天保十二 (1841) cited in Nakamura Tsukō 中村士, Satō Issai no tokei kenkyū to bakumatsu tenmongata to no kōryū　佐藤一斎の時計研究と幕末天文方との交流 (*Satō Issai's investigation of clocks and his interaction with Bakumatsu Astronomers*), in *Tōyō kenkyū* 東洋研究 (Oriental Studies), vol. 171 (January 2009), pp. 23-24.

notion of the "mean time."[420] At first, Yoshitoki made mathematical calculations, subtracting and adding the times of Greenwich, Amsterdam, Tenerife, Nagasaki, Kyoto and Edo, contemplating the longitudinal difference between them. At a certain point, however, he pointed out that the differences are in "mean time,"[421] and testing this new notion he compared between the data he obtained through observations and those of the English nautical almanac. His conclusion was that when one takes "common time"[422] it does not match the data of the almanac, yet when he used the mean time, the observational data and that of the almanac matched.[423]

After Yoshitoki's death in 1804, it seems that the notion of the mean time remained relatively dormant. Yet it was certainly not entirely forgotten. Shibukawa Kagesuke,[424] the younger of Yoshitoki's sons, who was adopted into the Shibukawa family of astronomers after Yoshitoki's death, made it his life's project to continue the work started by his father and his elder brother. Among his major achievements was finally finishing the translation of Lalande's *Astronomie* started by his father, publishing a detailed explanation of astronomical practices and devices used for the Kansei calendar reform of 1795, and devising his own calendrical reform in 1844 — the last one of the Edo period. His lesser known work is nevertheless central to the story of transformation of Japanese time. After discovering a "nautical almanac" by Jacob Swart in 1828, but spending several years keeping a low profile following the Siebold incident, Shibukawa Kagesuke wrote a short treatise, titled *Questions and Answers about*

[420] *Angeria reki kō* 諳厄利亜暦考(*Study of the English Calendar*) 享和元 (1801), Tohoku University Online Wasan Collection (http://dbr.library.tohoku.ac.jp/infolib/user_contents/wasan/l/a033/01/a033010031l.png last accessed April 2012).
[421] *Heiji* 平時, p. 16.
[422] The literal translation of the Japanese term 用時 *yōji* is actually "the time that is used," which assumes that this kind of time was in *common* use. For the sake of clarity and style I translate it as "common time," which I believe conveys the meaning of the term better than the literal translation.
[423] *Angeria reki kō*, p. 31.
[424] 渋川景佑 (1787-1856).

Chronometers.[425] Kagesuke begins his treatise by explaining the difference between solar time and sidereal time: "if [at a certain day] the first star in the star system of Polis is at its southernmost position exactly at noon, like the sun, then next day, after making one rotation, it will come back to it southernmost position a little *before* noon. In the same manner, day after day, it gradually outpaces the true noon." He then continues to say that the sun's movement is not constant either, yet it "has an average of approximately one degree in one day."[426]

Kagesuke's words were later echoed in Fujino Masahiro's 1861 translation of Jacob Swart's *Zeevaartkunde*. Fujino's work is certainly based on the Dutch book, but the author himself admits that "in order to make sense in Japanese" he had to change the text.[427] In the book titled *Explanation of Navigation Method*, Fujino makes a distinction between three types of time:

> Sidereal, solar and mean. Sidereal time is the time that it takes a certain star to come back to the same position after it passed the meridian. Solar is from one crossing of the meridian by the sun to another. However, the time that it takes the stars to complete one round is not the same as for the sun and it is faster by approximately one degree [….] But there is also difference between the solar and the mean time. The rate in which the sun moves westwards every day is not the same.[428]

But how do we know all the different types of time? According to Shibukawa Kagesuke, this is precisely the role of chronometer: "the hours of the Western miniature clock are determined by one revolution of the sun on the ecliptic to the same position it was before […] and calculating the [daily] average it comes to twenty four hours a day, [..] which is called 'mean time' […] But the hours used in Japanese calendars or announced by bells are all according to

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[425] *Jishingi montō* 時辰義問答, Tohoku University Kanō archive. Although the piece is not dated, an historian of Japanese astronomy, Nakamura Tsukō used the data mentioned in the text in order to calculate the year in question, and arrived at 1846.
[426] *Jishingi montō*.
[427] Iida Yoshirō, "Kōkai yōhō setsuyaku nitsuite shōkai 航海要法節約について紹介 (Introduction of "*Explanation of Navigation Method*")," in *Kaijishi kenkyū* 海事史研究 *(Journal of the Maritime History)*, vol. 25 (1975), p. 112.
[428] *Kōkai yōhō setsuyaku* 航海要法節訳(*Explanation of Navigation Method*) 文久元, (1861) Tohoku University Online Wasan Collection. http://dbr.library.tohoku.ac.jp/infolib/user_contents/wasan/l/i002/05/i002050104l.png last accessed April 2012).

the 'common time,'"[429] which Kagesuke explained as "sun's rotation from one southernmost position to another next day." Namely, the reason why there is a difference between the time of the chronometer and the time used in Japan is because the latter indicates "common time," also called "true time" by the Westerners, while the time of chronometer is a "mean time" – the average time of the solar motion. Here, the time indicated by a chronometer became the true, the real time, independent from any human activity or even from local noon visible to the eye. It is the abstract time defined by the mathematical calculation and maintained by the mechanical clock.

In order to make this point clearer, Shibukawa Kagesuke offers an example of such a difference and the calculations associated with it:

> "So, [what do you do] if you want to know what should be the time on the watch when you have measured the 'common' 12 o'clock as the true noon with the sun on its southernmost position, on the 7th of the first month, this year? First of all, looking at the universal time difference tables you see that Japan's difference is 14 minutes, 32 seconds (I explain the universal difference later). Consequently, adding the universal difference to the normal 12 o'clock (Usually, the universal time difference is used to determine the common time from the mean time, but here we take the common time as a reference point and infer the mean time from it. Consequently, instead of usual subtracting, we add the value), we get 12 o'clock, 14 minutes and 32 seconds. This is a mean time as opposed to the common time. Therefore, when it is 12:14:32 on the watch on the 7th of the first month of this year, you know that it is the ninth hour of the noon [according to the Japanese reckoning]"[430]

But what is this "universal time difference"? How do we calculate it? And where does the time start in the universe? As Fujino Masahiro puts it: 'for latitudes, the equator serves as a reference point, and all the latitudes are calculated from it. For longitudes, there is no such a place.' Therefore, he continues:

[429] *Jishingi montō*.
[430] *Jishingi montō*.

> Each country decides where [the time] starts. England set her prime meridian to the place called "Greenwich" where they have an observatory. But France sets its prime meridian to Paris, in Spain it is a place called Cadiz and the Dutch take the Pico of Tenerife. Recently, both America and Russia decided on Greenwich as their prime meridian.[431]

An obvious conclusion from the fact that every country decides how to measure the longitude, would be that Japan is entitled to do so by referring to its own time, in the same manner as it had already been done with determination of the longitude on the land in Inō maps. However, the author continued:

> Although our country obviously should measure its degrees relatively to Kyoto, our countrymen have not yet sailed abroad and therefore have not measured the longitudes and latitudes of various places. In a meanwhile, we use the longitudes and latitudes determined in England, and only after taking this as our reference point, calculate the latitudes to the position of Kyoto. According to English calculation, Kyoto is at 135'40 longitude.[432]

In these circumstances, as much as Japanese scholars would love to own their time, the practical considerations made it impossible. All the comparison tables pointed to the Greenwich time and the Western chronometers brought to Japan, including the one used by Siebold, all measured time according to Greenwich. The abstract time introduced with visions of navigation and chronometers was not only global, it started somewhere far away from Japan.

This gradual change in the notion of time was also reflected in the actual terms used to signify "time." The idea that geographical distance on the East-West axis could be translated into a difference in time was far from being new in nineteenth century Japan. As we have seen in the previous chapter, the seventeenth century astronomer Shibukawa Shunkai was preoccupied with this idea, focusing mainly on the difference in the times of observed celestial phenomena in China and in Japan. Yet the term that he used to talk about this equation was actually "difference

[431] *Kōkai yōhō setsuyaku*, http://dbr.library.tohoku.ac.jp/infolib/user_contents/wasan/l/i002/05/i002050009l.png last accessed April 2012.
[432] *Kōkai yōhō setsuyaku*, http://dbr.library.tohoku.ac.jp/infolib/user_contents/wasan/l/i002/05/i002050010l.png last accessed April 2012.

in *ri*" – *risa*.[433] Although the term *jisa* , "difference in hours"[434] was also used by Shunkai, it was overshadowed by *risa*, which came to signify the simultaneous difference in time and space. The term remained in use throughout the eighteenth century and was still used in 1798 by Takahashi Yoshitoki and Hazama Shigetomi in their letter exchange about the possibility of calculating the longitudinal distance by means of simultaneous observations. Yoshitoki also used it in his 1802 references to the English Nautical Almanac.[435] Nevertheless, Yoshitoki's and others' astronomical activities, the change in the perception of geographical space that followed, and the subsequent contemplation about finding one's location in the open sea brought about the gradual change in terminology.

Unlike terrestrial explorations, sailing in the open sea does not enable one to navigate by referring to visible landmarks. There are no physical landmarks at sea, and thus it is impossible to measure the distance, *risa*, between them. In this situation, time measurement, especially the Greenwich time indicated by the chronometer, served as a conceptual landmark that enabled the calculation of a location by measuring the time *between* two points —Greenwich and the location at sea. Consequently, when working on his father's attempts of formulating principles for finding longitude at sea, Shibukawa Kagesuke wrote that "using the tables of *hour-distance, jikyo,*[436] of the moving ship, one can estimate the radian by hour and visa versa."[437] Here, time was no longer defined just as units, whenever they are hours of any sort, minutes, *koku*, pendulum oscillations or other; it became an interval — an interval traveled by a ship.

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[433] 里差.
[434] 時差.
[435] Iida Yoshirō, "Kōkai yōhō setsuyaku nitsuite shōkai 航海要法節約について紹介 (Introduction of "*Explanation of Navigation Method*")" in *Kaijishi kenkyū* 海事史研究 *(Journal of the Maritime History)*, vol. 25 (1975), pp. 132.
[436] 時距.
[437] *Zoku kaichū funamichi kō* 続海中舟道考 (*Addendum to 'Study of sailing in the open sea'*). National Astronomical observatory of Japan.

In the final years of the Edo period we see the emergence of the modern Japanese word for "time" – *jikan.*[438] In his translations of Western navigation manuals, Tokura Sukeyuki talks about "jikan", or an interval between two moments, that it takes for a ship to travel. [439] The modern idea of time, therefore, is not a simple idea of duration. As we have seen in the previous chapters, all the other temporal terms used by both astronomers and amateurs— *ji, toki, koku, jikoku, jibun* — all of those could be used to signify time duration. Rather, the interval, the *kan* in *jikan*, refers to the actual and physical space that stretches in distance in the open sea between two different temporal landmarks. And it was this idea that conceptually linked time and space that stood at the basis on the modern Japanese word.

Conclusion

> Absolute, **true** and mathematical time, in and of itself and of its own nature, without reference to anything external, flows uniformly and by another name is called duration.
>
> Absolute space, of its own nature without reference to anything external, always remains homogeneous and immovable.
>
> In astronomy, absolute time is distinguished from relative time by the equation of common time. For natural days, which are commonly considered equal for the purpose of measuring time, are actually unequal. Astronomers correct this inequality in order to measure celestial motions on the basis of a **truer** time.[440]
>
> Isaac Newton, *Principia Mathematica*.

Newton's "true" time was neither true nor absolute; it was built on a series of cultural assumptions about time and universe, and equally cultural association of mathematics with universal validity and truth. Needless to say, these assumptions and associations were unique to

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[438] 時間.

[439] *Detailed Revelations on Navigation* (航海啓微 Kōkai keibi) and *Secret Readings in Navigation* (航海必読 Kōkai hitsudoku), late Tokugawa period. Tohoku University Wasan Online archive.

[440] Sir Isaac Newton, *The Principia: Mathematical Principles of Natural Philosophy*, I. Bernard Cohen and Anne Whitman, trans., (Berkeley: University of California Press, 1999), pp. 408, 410. My emphasis.

Western European culture, and unsurprisingly absent from the arsenal of practices, assumptions and associations used by Japanese astronomers in the eighteenth century. As we have seen in the chapter three of this study, Japanese astronomical times of the eighteenth century were very different from the above definition provided by Newton.

Yet European assumptions about the nature of time were interwoven into astronomical practices that found their way to Japan at the end of eighteenth and beginning of the nineteenth century. By recreating those practices, Japanese astronomers reconstructed the tacit assumptions embedded in them; and by carrying over timekeeping practices from one field to another they arrived to new conceptualizations of space and time, which were not identical but certainly reminiscent of the European ones.

It all started with one practical calculation problem — finding the value of one meridian degree for the latitudes of Japan. From there, Japanese geographers and aspiring navigators used their knowledge of astronomical timekeeping as a conceptual stepping stone. Driven by their calculations and the qualities of the pendulum clock, they arrived at a notion of continuous space, which was came to be unified by the flow of time and the commonly observed celestial phenomena, and bound to one cultural center. Encouraged by their findings on earth, scholars expanded their investigation of space into the open sea, and molded the idea of defining the space through time to fit the practical conditions on the board of the unsteady ship. They found additional embodiment of this idea in the chronometer that kept the mean time, and finally, succumbed to the authority of Western data oriented to Greenwich.

By then, the time has changed. Moreover, it is even possible to say that in a certain sense "the time" has emerged — that is, the modern notion of time. There was actually nothing inherently "modern" about this kind of time — it didn't represent modes of production or

disassociation from the supernatural, and neither was it more distant from "nature" than the previously existing notions of time. But it was a notion of time that stood at the basis of time-related practices developed in the West, and this notion was reconstructed through the recreation of similar practices in Japan. Accidentally, this was the notion that came to dominate the modern world, both in the West and in Japan. The time itself was not modern, it was just the kind of time we use in the period we decided to call "modernity".

There was no Westerner who propagated this notion of time in Japan, and there was no Western text that explicitly instructed Japanese how to perceive time. Nor can we say that it was created solely by the mechanical clock — as we have seen in chapter two, when detached from cultural context and associated practices, mechanical clocks failed to instill European time in Japan. However, the bits of Western knowledge, combined with instruments that embedded the worldview of their creators, created a kind of puzzle, which began showing the coherent picture behind it, in spite the fact that many pieces were still missing. Having seen the available pieces, which suggested a similar rationale and ignored similar points, Japanese scholars were able to infer the missing parts by mentally completing the empty spaces and thus reconstructed anew the conceptual scheme that stood behind Western science.

Chapter 5: The Lure of the Machine

Why Clocks?

Previously we have seen how scholars' appropriation of broader astronomical practices and considerations shaped astronomical timekeeping technology and practices, altering the underlying meaning of the general algorithm called "time". Astronomers, geographers and aspiring navigators carried over practices from one sphere of natural investigation to another, reshaping significance and meaning of timekeeping, time and clocks.

But clocks, astronomical, navigational, or those for everyday use, were never restricted to one specific sphere of practice, or even several related spheres — the mere fact that they were used, or even just seen or heard of, by a large number of people means that they belonged to a broader cultural imagery, evoking certain associations, expectations and values.

Among historians who deal with Japanese clocks, in one way or another, there is no disagreement about the fact that mechanical clocks were desirable and valued objects. The question is "why"? What made mechanical clocks so special? If clocks served as status symbols, what made them a worthy candidate for this status? Some said the clocks provided superior technological advantage, others claimed clocks were rare, exotic and mysterious. The value of artifacts, however, is not an inherent part of them but something attached to them by representatives of various social groups and historical societies. Consequently, if we want to understand why clocks were valued, we need to examine what were the clocks associated with, and how these associations changed throughout the years.

One major quality of clocks, that set them apart from other artifacts, was that clocks were a species of "machines"— they were mechanical, they had moving weights and gears, and they

produced a requested result without constant manipulation by humans. Yet the particular interpretations and associations related to the category of "mechanics" also changed with time, transforming with it the values attached to one specific mechanism — clocks. Throughout the Edo period clocks maintained a rather high status, yet the reasons for this appreciation for mechanical timekeeping device changed following the cultural associations attached to various "machines".

Practical Disaster

If practicality was the main driving force behind popularity of technologies, mechanical clocks would have never taken root in Japan. As have seen in the second chapter, they were expensive, cumbersome, often in need repairs, and required constant maintenance to prevent them from running too quickly or too slowly. If practicality was motivating people, they would have probably found it easier to just carry a simple, cheap paper sundial to supplement the announcement of time by public bells.

One could, of course, claim that the clock had obvious advantages over all non-mechanical timekeepers: it could have continuous motion, could be used during the night, and was not affected by the weather.[441] Indeed, Edo-period users were not oblivious to the shortcomings of non-mechanical timekeepers, pointing out the effects of environment on various modes of non-mechanical time-measurement. [442] But the clocks were not perfect either – their continuous motion was potential, but in fact they had to be manually adjusted at least once every fifteen days, and in most of the cases it would be once every couple of days or even twice a day.

[441] See, for example, Landes, *Revolutions in Time*.
[442] See, for example, *Jūniji shōko kono sū* (The numbers of tweleve hours of bells and drums).

The invention of the *shaku* clock, which in principle could not have had continuous motion for more than one day, makes clear that this continuity of time measurement was simply not seen as an essential or advantageous characteristic of time-keepers. In this sense, there was no difference between re-winding a mechanical clock and setting an incense clock every morning. And the clocks were not necessarily more reliable either: as mentioned above, they were prone to rust and wear, and often ran too slowly or too quickly, and some pointed out that clocks, too, were prone to "the influences of heat and cold, dampness and dryness."[443] Consequently, the clocks were sometimes adjusted by comparing them to incense timekeepers, while bell-keepers had an incense timekeeper alongside mechanical clocks in their towers to ensure that there would be no mistake in public time-telling as a result of mechanical failure.[444] It is no wonder, then, that even people like Endō Takanori, an early nineteenth century official in Kaga province, who not only *used* clocks for his land surveys but also *built* clocks on his own, stated that although clocks were useful for keeping time during the night, they could simply be replaced by an incense timekeeper or a sundial.[445] Sundials didn't have the disadvantages of mechanical clocks— they weighed much less than the smallest pocket watch, and unless smashed or torn, they couldn't get out of order. Combined with the omnipresent sound of time bells, sundial served as very convenient indicator of time for a traveler or even for one whose work required frequent absence from home or office.

Moreover, previously we have seen that mechanical clocks were remodeled to resemble non-mechanical timepieces in their appearance. So, if the clocks were inconvenient, if there were

[443] Kyūshidō Shūjin, *Shōchū jishingi*.
[444] Urai Sachiko, *Edo jikoku to toki no kane*, pp. 172-192; Hashimoto Manpei 橋本万平, *Nihon no jikoku seido* 日本の時刻制度 (Japanese Time System) (Tokyo: Kosensho, 1957), pp. 157-170.
[445] Endō Takanori 遠藤高璟, *Kanazawa Jishōki* 金沢時鐘記 (The record of bell-keeping in Kanazawa), 文政六 (1823), Shin-Imizu Museum, Kōju Bunko Archive.

other means to measure time, and if these other, non-mechanical timepieces even *looked* more the way a timepiece should look like, according to the Edo period standards, then why bother to make all the adjustments to the mechanical clock? Why would they even bother to solve the problem of incompatibility of European clocks with Edo Japanese temporal systems? It seems though that the clocks thrived not because of their practicality but rather *in spite* of their impracticality for everyday time-keeping.

Availability of the clocks

But perhaps non-mechanical timekeepers were still in use simply because clocks were too rare and unavailable? Indeed, it is often suggested that mechanical clocks were "Daimyō Clocks,"[446] namely owned only by the rich and highbrow. Undoubtedly, high status and wealthy people were among the primary clientele of clock-makers, but looking at an array of sources, it is hard to believe that they were the only ones. None of the Edo period sources surveyed in this study mentioned the term "Daimyō Clock", an unlikely term to be used during that time;[447] instead these were just "clocks", used by representatives of various social strata.

The modern-day idea that in the Edo period clocks were exclusively owned by the *daimyō* is closely related to another misconception — that clocks were extremely rare. It is not unusual that the mentioning of Edo-period clocks evokes a skeptical question: "how widespread were clocks in the Edo period?" This question is impossible to answer, however, because more than two hundred and fifty years of clock production and consumption were far from being static. Edo-period contemporaries themselves were quite aware of the change in the availability

[446] "Daimyō" is a title of provincial governors.
[447] In general, the term *daimyō* was not widely used in Edo period. Instead, people used honorific suffixes such as *tonosama* 殿様 or *ontono* 御殿 after the names of high-ranking lords. It was only in the twentieth century that this term became prevailent in both the popular culture and the academic literature.

of the clocks. Writing already at the beginning of the eighteenth century, the mathematician Nakane Genkei[448] noted that "some clocks imported during the Kanbun era (1661-1672) were locked up in government storage and no one had seen them. But since the final year of Hōei era (1710) these were examined and studied to their final details. Then they became extremely popular and widespread".[449]

It is certain that by the end of the eighteenth century the mechanical clock itself was not a rarity. Thus, for example, the author of *Clock Pictures* goes into lengthy explanations about the structure and the use of *Rōkoku* (clepsydra), but then provides the picture of a mechanical clock accompanied by the description "this is what we use today."[450] In contrast, the author of *Illustrations of Various Measuring Devices* stated that he initially did not mean to include an image of a clock at all, since he thought it to be too trivial, and he only added the picture because of the constant criticism of his readers, who were unsatisfied with its absence.[451] Then, a clockmaker who produced a round-graph *shaku* clock in 1834 simply inscribed on it that "nowadays, there is no professional who does not own a clock."[452]

Looking at the surviving Edo-period clocks today, it is fairly easy to conclude that clocks were objects of luxury, since many of the clocks in current museums and collections are made of expensive materials and heavily ornamented, or of an exceptionally large size. Yet, we should not forget that when Edo-period clocks were made obsolescent by Meiji period reform, many of them were simply thrown away, and it was precisely the high value of luxury clocks that

[448] 中根元圭 (1662-1733).
[449] Nakane Genkei 中根元圭, *Jikokuron* 時刻論 (Treatise on time), date unknown, Tohoku University Library Online Wasan Collection
[450] Anonymous, *Tokeizu* 時計図 (*Illustrations of Timepieces*), date unknown, Tokyo National Museum Archive.
[451] Nishimura Tōsato 西村遠里, *Sokuryō sho ki zu* 測量諸器図 (Illustrations of various measuring devices), date unknown, National Astronomy Observatory of Japan Archive.
[452] Kondo, Katsuno, "Furiko en gurafu shiki mojiban kakedokei", p. 5.

prevented their owners from simply disposing of them. The fact that Edo-period mechanical clocks are easily found today and usually displayed in dozens, including simpler and less extravagant devices, indicates that at least by the nineteenth century their use went far beyond the thin stratum of wealthy officials. Clocks are not different from other museum exemplars such as pottery or laquerware — the existence of the state-of-art object does not imply that there were no simpler versions used by people of humbler status than the *daimyō*.

Moreover, seeing that non-mechanical timepieces, such as sundials, were also made into objects of luxury, it seem that there was no clear-cut hierarchy between the mechanical and non-mechanical timepieces. Rather, the hierarchy was between the more expensive and the less expensive timepieces, and the fact that some chose to spend substantial sums of money on gilded and ornamented sundials means that they didn't think of a sundial as a poor-man's choice.

Another indication of the popularity of clocks is the growing availability of clock masters in the urban centers of Japan. If we are to believe the *History of Owari Domain*,[453] written in 1832, the first Japanese clock master was a certain ironsmith, Tsuda Sukezaemon,[454] who repaired an imported clock for the first Tokugawa shogun, Ieyasu. Following this event, Ieyasu hired Sukezaemon to work exclusively on clocks, thus creating the profession of clock-makers in Japan.[455] Sukezaemon established a hereditary line of clock makers (all named Tsuda Sukezaemon) who were employed by the Owari domain until the beginning of the Meiji period in the mid-nineteenth century.[456] None of the members of the Tsuda family was, however, mentioned in contemporary literature as a famous clock master. Instead, there were several other

[453] *Owari-shi* 尾張志.
[454] 津田助左衛門.
[455] We should mention the fact that the *History of Owari Domain* was written more than two hundred years after the events and that it praised a compatriot, which somewhat undermines its reliability.
[456] During the research Yamaguchi met with the heirs.

families of clock-makers in Edo, Kyoto, Osaka, Nagoya and Nagasaki who seem to have flourished in their profession.[457]

Clock masters are mentioned in the popular shopping guides of Edo and Kyoto already in the beginning of the eighteenth century.[458] In the nineteenth century clock-makers' shops were mentioned alongside shops selling clothes, lacquer boxes, utensils, smoking supplies etc., which indicates that clocks were not seen as exceptionally unaffordable items.[459] Note also, that the shopping guides only listed the *famous* and *recommended* shops, so in the same manner as we can assume that there were probably more than two stores selling the very popular fireworks in the whole city of Edo with its population of over a million people, there were also more than four clock-makers.[460]

It is hard to specify the average price of a clock, since clocks varied greatly in their shape, size, and materials, as well as perhaps the status of the owner. The Dutchman Isaac Titsingh, who stayed in Japan in the 1770's and 80's, wrote that he wanted to buy a Japanese clock to bring back to Europe, but he gave up the idea, since the clock he was asking about was too expensive. [461] Yet, we don't know what kind of clock it was or whether the price requested from Titsingh was representative, since it is highly probable that a merchant could have requested a ridiculous amount from a wealthy looking foreigner. On the other hand, in another case, in a

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[457] Mody, *Japanese clocks*, p. 44.
[458] Bedini, "The Study of time", i*n* J. T. Fraser, F. C. Haber, G. H. Müller. Ed. *The Study of Time : proceedings of the second conference of the International Society for the Study of Time* (Berlin ; New York : Springer-Verlag, 1972) p. 458.
[459] Nakagawa Gorōzaemon 中川五郎左衛門, *Edo kaimono hitori annai* 江戸買物獨案内 (A single guide to (all) Edo shopping). Kobe University Digital Library (http://www.lib.kobe-u.ac.jp/directory/sumita/00018117/ last accessed April 2012).
[460] Ibid.
[461] Isaac Titsingh, *Illustrations of Japan; consisting of private memoirs and anecdotes of the reigning dynasty of the Djogouns, or sovereigns of Japan; a description of the feasts and ceremonies observed throughout the year at their court*, translated from the French, by Frederic Shoberl (London: Printed for R. Ackermann, 1822), Princeton Rare Books Collection, p.159.

letter to a friend, an astronomer Asada Gōryū[462] complained about the high price of the clock that he had ordered. The clock cost him 1.2 *ryō*, which could pay for one luxurious night at the pleasure quarters and is equivalent to approximately 200,000 yen in today's currency.[463] Not cheap, certainly. And even though Gōryū was able to pay right away, he still requested reimbursement. Nevertheless, noting that it was a custom-made, ornamented astronomical clock that had to answer to specific demands and the production of which lasted for half a year, this price does not seem to be extraordinarily high.[464]

The idea that Edo-period mechanical clocks were rare and expensive status symbols of the few individuals of the highest social rank is therefore based on a very selective reading of sources and selective viewing of the surviving devices. This selective vision was undoubtedly fueled by the modern bias according to which "mechanical", especially "mechanical clocks" is equated with "modern", "abstract" and "capitalist".

Beyond Exotics and Mystery

But let us return to our original question – why would anybody spend large sums of money on a cumbersome product, when it was possible to use less expensive but not less reliable non-mechanical methods of time-keeping? Even when we take into account the increasing precision of clock-mechanisms imported from the West, this precision was simply too fine in terms of the precision range needed in the Edo period.

One possible way of interpreting the interest in the movement of the clock would be to view it as a kind of amazement at the sight of what was considered a Western curiosity. This

[462] 麻田剛立 (1734-1799).
[463] Approximately U.S. $2300.
[464] Uehara, Hisashi ed., *Tenmon rekigaku shoka shokanshū* (Collection of various astronomers' correspondence), (Tokyo: Kodansha, 1981), pp. 30-32. The letter is dated as "seventh month, twenty second day", with no indication of a year.

explanation seems very plausible, as Edo-period Japanese indeed had a taste for rarities, including those imported from the West. Furthermore, the mechanical clock was undoubtedly the first automatic device seen in Japan, and it would be only natural to expect that its independent function caused quite an excitement.[465] Indeed, some of the sources from the sixteenth century mention how Japanese rulers were astonished when presented with a clock. Yet this sense of great astonishment is much more apparent in sources written by Westerners, and even they sometimes admit that the Japanese often took a much more pragmatic approach than they had expected. Looking at Japanese sources we find that although the fact that the clock could strike hours on its own definitely left an enormous impression, another characteristic of the Western clock, namely the fact that it failed to "distinguish between day and night hours,"[466] seems to have had no less an impact.

Yet these sources, both Western and Japanese alike, only tell us about the initial impression made by the mechanical clock in the sixteenth century. The image of the mechanical clock, and specifically the association of it with the West, changed throughout the two hundred sixty-three years of the Edo period. As we have previously seen, even though a large number of mechanical clocks were imported from the West, their appearance and modes of measuring time were altered to fit Japanese standards, losing strikingly "Western" attributes. As Nakane Genkei described it: "even though the clocks were originally brought from the West, nowadays it is impossible to know where they come from, since foreign digits were replaced with our numbers and the animal signs."[467] Surely, if the foreignness of the clocks was seen as a desired feature, the foreign attributes would have been stressed, not discarded. And this is exactly what happened

[465] Screech, Timon, *The lens within the heart: the western scientific gaze and popular imagery in later Edo Japan* (Honolulu: University of Hawai Press, 2002), pp. 78-80.
[466] From the records of Ouchi Yoshitaka, cited in Hirai, *Tokei no hanashi*, p. 120
[467] Nakane Genkei, *Jikokuron.*

at the very end of the Edo period, when Western watches were carried around *as they were*, without any alteration, and even though their owners could not use them as time keepers, not knowing how to read time off of the Western dial.[468] And although there was no question about their time-keeping function, as it was acknowledged that they were a variety of clocks (*tokei*), they were still treated as belonging to a somewhat different category than the Japanese clock, even receiving their own name — *jishingi*, a "time machine."[469]

Another hypothesis concerning the reason for the popularity of the clocks is the mystery behind their motion. One piece of the evidence usually cited in favor of this thesis is that that the device was frequently referred to as *jimeishō*[470] or "self-sounding-bell," a name that reflected a fascination with the unique quality of the clock to strike the hours on its own. Yet as Hashimoto Manpei points out, the term was in use in Japan already in the Heian period and referred to non-mechanical devices triggered by water or incense, and were designed to sound at appropriate times.[471] The earliest Japanese records mentioning mechanical clocks, such as the records of Ōuchi Yoshitaka or the record of the Jesuit gift to Toyotomi Hideyoshi, do not mention the term *jimeisho* at all, using instead one of the character combinations of the Japanese word *tokei* - clock.[472] Later sources often do mention the term, but also specify that *jimeisho* is none other than *tokei*. For instance, Terajima Ryōan, the author of *Sino-Japanese Illustrated Encyclopedia* wrote that "the Western monk Matteo Ricci had a jimeishō,"[473] adding an inscription "*tokei*"

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[468] For more extensive discussion of these foreign clocks see chapter six.
[469] 時辰儀. See chapter six for a detailed discussion of foreign watches and their reception in the nineteenth century.
[470] 自鳴鐘.
[471] Hashimoto Manpei, *Nihon no Jikoku Seido*, p. 84.
[472] Most historians writing in Japanese mention the terms *jimeisho* while citing some early sources, but all these sources are, in fact, translations of Western ones, such as Frois' *Historia de Japao*, and I suspect that the application of the term *jimeishō* here is anachronistic.
[473] Terajima Ryōan, *Wakan sansai zue*, 1713, republished by *Nihon Zuihitsu Taisei Kankōkai, Tokyo*, 1929, p. 248. Also Kyūshu University Online Collection (http://record.museum.kyushu-u.ac.jp/wakan/wakan-jin/page.html?style=b&part=8&no=7 last accessed April 2012)

next to the characters of "*jimeishō*" to indicate that this device was, in fact, a clock. But even more importantly, the existence of the term and its continuous use in the Edo period does not necessarily indicate same kind continuous fascination with the wondrous function of striking the hours without (the immediate) touch of a human hand. After all, many terms are largely conventional and though they reflect a certain etymology, they no longer carry the connotations that were originally embedded in them.[474]

Clocks in Print

Starting from the end of the seventeenth century, more and more clocks began to appear in print, becoming a familiar sign in the published world. It was not only the frequency of clocks' appearance that increased; the places where clocks appeared and the role clock depictions played, indicate the changing attitudes towards clocks throughout the Edo period.

First depictions of clocks appeared in the popular "useful" literature — encyclopedias, catalogues, and guides. In 1690, clock makers and their products appeared in the *Encyclopedia of Professions*[475] in the volume that described artisans. Lined up with knife-sharpeners, umbrella-makers and woodblock-carvers, clock-makers are depicted as just one of the numerous professionals one can see on the streets of Kyoto. Similar depictions of clocks are seen in popular shopping guides that were mentioned earlier in this chapter. Clocks were also mentioned

[474] Take for example the word "orientation" that is only incidently used to mean anything to do with the East, and most often bears a meaning of "introduction to" or "explanation". And it is highly doubtful that somebody going to an "orientation" should expect to be critical of "orientalism".

[475] Makieshi Genzaburō 蒔絵師源三郎, *Jinrin kinmōzui* 人倫訓蒙図彙 book 5, "Artisans". 元禄三 (1690) Kyoto University Digital Library, Rare Materials Exhibition (http://edb.kulib.kyoto-u.ac.jp/exhibit/i101/image/05/i101s0105.html last accessed April 2012).

in the popular *Sino-Japanese Encyclopedia*[476] published in the beginning of the eighteenth century. All these depict clocks as an object used by humans for their various purposes.

At the same time already in the end of the seventeenth clocks began appearing in novels. The role of clocks as literary devices changed throughout the time, echoing the popular sentiment towards the clocks in the general public. The famous writer of the end of seventeenth century, Ihara Saikaku, seemed to be fond of clocks and used them in his *The Eternal Storehouse of Japan* or *The Life of Amorous Man*,[477] weaving them into the plot of his writings as signs of extravagance and urban pleasures. In the similar manner the authors of the famous, early eighteenth century puppet play *The Tale of the Forty-Seven Rōnin*,[478] disguised their pungent critiques of recent political events in medieval setting of the story; yet in the middle of the play they planted a mechanical clock, indicating that this episode could only have happen in recent times, when people already used sophisticated mechanical devices such as clocks. Here too, the clock was a symbol of "modern" for that time, period.

Later, Nishikawa Sukenobu[479] portrayed clocks as tools of power. In his stories he described courtesans in pleasure quarters, who manipulated clocks in the pleasure house in order to make their lovers stay longer or urge the unwanted customers to leave sooner. The clock in his stories is no longer a novelty and rarity — it is just because people came to rely on clocks that they could be used by courtesans as tools of manipulation.

[476] *Wakan Sansai Zue* 和漢三才図絵.
[477] Ihara Saikaku 井原西鶴, *Nippon Eitaigura* 日本永代蔵, 貞享五 (1688), and *Kōshoku ichidai otoko* 好色一代男, 貞享元 (1684).
[478] Takeda Izumo 竹田出雲 et al. *Kanadehon chūshingura* 仮名手本忠臣蔵.
[479] 西川 祐信 (1671-1750).

In late eighteenth century Jippensha Ikku[480] also described courtesans who handled mechanical clocks, albeit with the different message. Playing on popular sentiments of the *Mind-and-Heart Learning*,[481] which propagated close attention to one's inner motives, Ikku told a story of righteous prostitute who managed her life as well as morals according to the clock. Here the clock played an important role as a metaphor for the human heart, and as a symbol of righteousness and diligence.[482]

A culmination of the clock's appearance as a literary device can be seen in the work of Santō Kyōden, [483] who often used clocks as symbols of temporality, of times to come or to pass. Santō Kyōden not only mentioned clocks but also worked to incorporate them into his illustrations and used them as a visual clue to the possible plot developments.[484] For Kyōden, clocks were no longer a symbol of modernity, or a reflection of the inner state of the soul, they were objects embedded in human life and bound by a set of temporal associations.

When we analyze the images of the clocks appearing in print in the end of seventeenth and eighteenth century we notice a curious set of tendencies.[485] It seems that at first, clocks were entering the public consciousness and had to be created as a new, though legitimate category. Then, clocks became a symbol of technological novelties and sophistication, a desirable and powerful object. Evolving into a metaphor of proper function, clocks were no longer perceived as exclusive, and by the end of eighteenth century, they came to assume a metaphor of a "true"

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[480] 十返舎 一九 (1765 -1831).
[481] *Shingaku* 心学.
[482] An extensive and excellent discussion of clocks in literature can be found in Timon Screech, *The Lens Within the Heart* (Honolulu: Hawaii University Press, 2002).
[483] 山東京伝 (1761-1816).
[484] For an excellent discussion of Santō Kyōden's use of clocks see Dylan McGee "Turrets of Time: Clocks and Early Configuration of Chronometric Time in Edo Fiction," in *Early Modern Japan*, vol 19, 2011, pp. 44-57.
[485] My analysis is based on the abovementioned secondary sources and well as on the list of clock illustrations in literature mentioned in Suzuki Nei 鈴木寧, *Edo Meiji shosetsu no tokei ga* 江戸明治書册の時計画 (Clock illustrations in Edo and Meiji literature) (Hirosaki: Roku no fue mamehon no kai, 1999).

state of affairs. Throughout the Edo period, authors could count on the practical and temporal associations that they expected clocks to evoke, and used the popular sentiments towards the clock in order to create the desired literary effect.

The Cult of Automata

The fact that Edo period Japanese did not perceive mechanical movement as miraculous could be best seen in light of Japanese automata, *karakuri ningyō.* Automata seemed to play a major role in Edo culture of entertainments. Broadly speaking, the word *karakuri* can refer to any kind of complicated device — a stage of kabuki theater that enables the actors to disappear suddenly, a magnetic compass, a secret box that requires one to solve a riddle, and, of course, any kind of device that contained gears. *Karakuri* didn't necessarily have to be mechanical, and devices operated by an intricate set of strings perfectly qualified to be a *karakuri*. In fact, most of the automata dolls were not entirely mechanical but rather operated through strings attached to moving gears. Moreover, it was the strings not the gears that enabled subtle motions of puppets' heads and hands, creating the illusion of a puppet contemplating the final touch to calligraphy or aiming to fire his arrow. It was these effects that provoked the most excitement among the audience and entitled mechanical art with the superlative description of "exquisite precision" — s*eimyō*.[486]

As we can see in the example of the famous spring-driven *Tea Bringing Doll* featured in Ihara Saikaku's verse from 1674[487] automata was popular already in the seventeenth century. By the beginning of eighteenth century, automata theaters became a familiar phenomena and some

[486] 精妙

[487] 独吟百韻 "ゼンマイの車細工にして、茶台をもたせて、おもうかたへさし向えしに、眼口のうごき、足取りのはたらき、手をのべて腰をかがむ、さながら人間のごとし. Tatsukawa Shōji 立川昭二 et al, ed., *Zusetsu karakuri : asobi no hyakka* 図説からくり : 遊びの百科全書 (*Illustrated —karakuri: the many objects of play*) (Tokyo: Kawade Shobo Shinsha, 2002), p. 38 .

automata makers, such as Takeda Ōmi, achieved such a high degree of fame that their name was repeated with admiration for generations to follow. Images of automata also began appearing in print, and in 1730 an *Encyclopedia of Automata*[488] was published, presenting the reader with the fantastic possibility of automata who played musical instruments, writing calligraphy and performing acrobatic tricks. Some seventy years later, *An Illustrated Manual of Curious Machines*[489] dedicated its second half to the inner structure of various automata. By the nineteenth century mechanical dolls and devices were rather widespread and produced by several masters. The title of the most famous one belongs however to Tanaka Hisashige, whom we met in the previous chapter. If previously, one could doubt whether automated dolls were actually constructed, Tanaka Hisashige left us with many exemplars of working dolls, automated fans, guns, looms, lamps and, of course, clocks.

A famous tea-bringing boy, an arrow-shooting samurai and a calligraphy writing scholar were all among the greatly popular models of these Edo period automata.[490] As a moving doll, which was purposefully designed to act like a miniature human-being, these were much more likely than clocks to be perceived as a wonder or miracle. However, similarly to the clocks, their design proves the contrary. If the purpose of automata shows was to create a miracle-like event, their masters would have disguised the fact that they were driven by a mechanism; but in fact they purposefully created parts that would point to the mechanical nature of the doll. For example, the arrow-shooting samurai is situated on a pedestal, with a smaller doll beneath him that looks like it is causing the samurai doll to move by turning a wheel. This wheel is, of course,

[488] Tagawa Kachusen 多賀谷環中仙, Kawaeda Toyonobu 川枝豊, ill. in *Karakuri Kinmō Kagamigusa* 璣(からくり)訓蒙鏡草 (Encyclopedia of Automata) 享保一五 (1730). Waseda University online collection of Chinese and Japanese Classics (http://archive.wul.waseda.ac.jp/kosho/i13/i13_00906/i13_00906.html last accessed April 2012).
[489] *Kikōzui* 機巧図彙 written by Hosokawa Yorinao in 1796.
[490] The first explicit mentioning of such a device is in a 1675 novel by Ihara Saikaku.

itself also moved by the central mechanism, but it was placed there by the designer in order to hint at the mechanical structure inside the device. Consequently, the automata masters displayed not only the dolls themselves but also their *mechanical* skill. It was not the effect of the movement alone that impressed the audience, but also the very knowledge that it was caused by sophisticated mechanical craftsmanship, and precisely *not* by "magic." Nothing illustrates this point better than stories of less skilled puppeteers who could not produce such devices, and had to resort to attaching fake wheels to their puppets in order to satisfy their audience's taste for the mechanical, while in fact the actual movement was caused by concealed manual manipulation.[491]

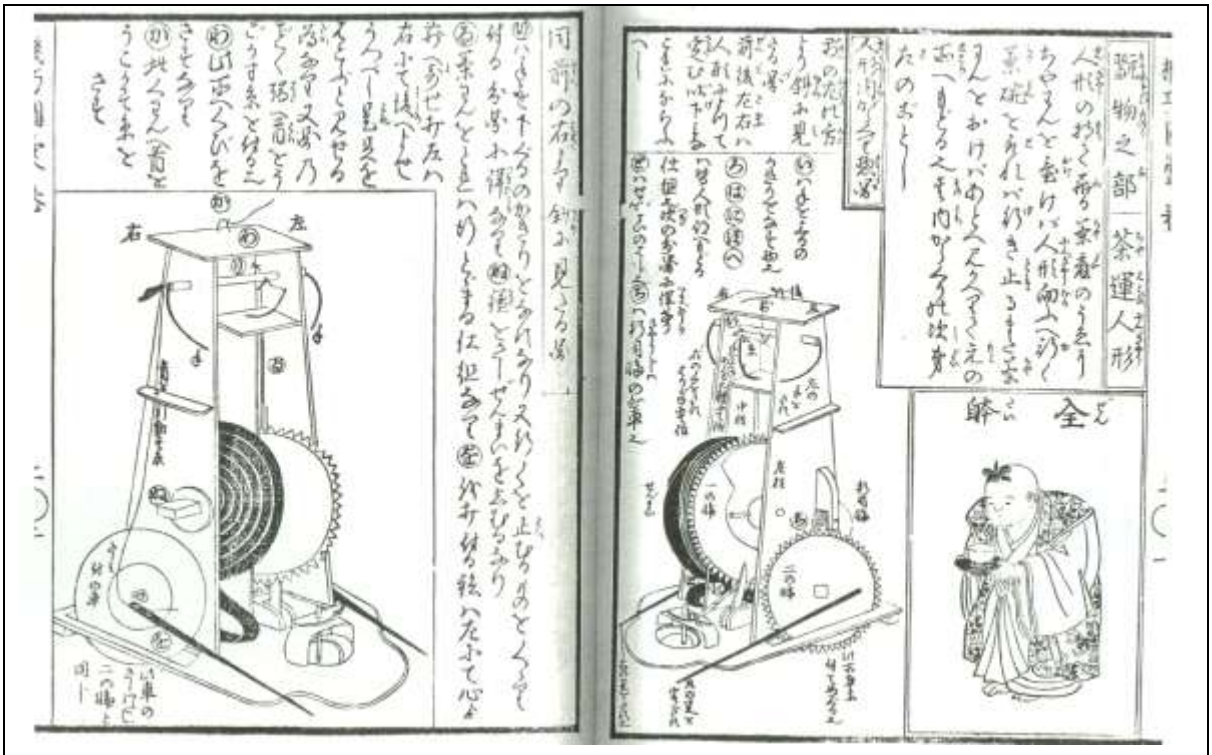

Image 13. The Tea-Bringing Doll (*Cha hakobi ningyō*) from *Illustrated Manual to Curious Machines*.

The text explains the function of each part and the way those were connected. However, lacking measures and omitting the practices of construction, this guide could not have assisted an amateur in constructing an automata of his own.

[491] Chaiklin, *Cultural Commerce and Dutch Commercial Culture*, p. 112

Can we assume, then, that clocks were perceived as a variety of automata? The sources certainly suggest a close relation between the two arts. Not only were most automata masters also clockmakers, in addition we note that *Illustrated Manual to Curious Machines* dedicated its second and third volumes to automata. According to this book, the clock is the basis of all mechanical devices, and therefore it first explains in detail the structure of clocks, although the parts dedicated to automata are not as detailed. However, the book's focus on the different functions of clocks and automata reveals a major difference in the goals of their making. In building an automata, *karakuri ningyō*, the most important thing was to make it look as animate as possible. Its charm was in resembling a mechanical version of human or, in certain cases, animal behavior. The appeal and excitement were precisely due to the sense of discrepancy between being mechanical and animate. The clock's appeal, on the other hand, was precisely in the fact that it was a machine performing a human function. This major difference might be the reason why the two devices were rarely combined in Japan, unlike in China or the West.[492]

Although the Japanese interest in the two types of devices might have sprung from the same source of admiration for exquisite craftsmanship and the mechanical look, they occupied different realms. Automata belonged to the realm of spectacle and were presented in public theaters, but were rarely owned by private people, even if they could afford them. The clock, on the other hand, was not a public device. It was owned by well-to-do individuals and was made clearly visible to their house guests even if it not directly displayed. It marked the highest degree

[492] Katherine Pagani *Eastern Magnificence and European Ingenuity: clocks of late imperial China*, (Ann Arbor: University of Michigan Press, 2001) describes Chinese clocks that often combined elaborate automata theaters with a clock. A clock, in these cases, was much smaller and sometimes even barely noticeable, compared with the whole structure that could contain landscapes with multiple moving figurines. In these Chinese clocks, the clock seemed to be just a pretense to construct an elaborate scene, and the frequent combination of clocks with automata suggests that the two belonged to the same kind of category, and evoked similar associations. This, however, was not the case in Japan. A possible comparison of the very different routes of development Japanese and Chinese clocks took is certainly worthy of further exploration, but unfortunately it lies beyond the scope of this dissertation.

of technological advancement and thus served as a visible, though not openly stated sign of sophistication.

Mechanical Leisure

Yet, at the end of the eighteenth century, we witness the emergence of another genre—genre that focuses on the structure of clock mechanism. The main representative of this genre was *An Illustrated Manual of Curious Machines*, first published in 1796.[493] Although some present-day historians describe *Illustrated Manual of Curious Machines* as a professional guide to the construction of mechanical devices,[494] and others see it as disclosing the secrets of the profession,[495] the content of the book reveals that it could neither be useful to professionals nor threatening to their secrets. Rather it was aimed at amateurs interested in technology.

The book mentioned widely known types of clocks, explaining technology that was in some cases at least a hundred years old, omitting newer innovations and improvements. Thus, for example, it explained the construction of a single-balanced clock, disregarding the already existing double-balanced ones. In the case of more recent technology, that of a spring-driven pillow clock, the author omits the explanation of the inner mechanism altogether. The book also omits some proportions and specific measures, making it insufficient for somebody lacking any mechanical knowledge. On the other hand, it does not merely describe the clocks or praise their functions, but rather goes into many technical details, down to the level of every wheel and nail, in a way that would probably have bored a complete novice. To summarize, the content of the book was probably too obvious to be useful for professionals, but not detailed enough to

[493] Hosokawa Hanzō (Yorinao) 細川半蔵(頼直), *Karakuri zui* 機巧図彙, 1796 in Aoki Kunio et al, ed. *Edo kagaku koten sōsho*, vol. 32 (Tokyo: Kowa Shuppan, 1976).
[494] Chaiklin, *Cultural Commerce and Dutch Commercial Culture*, p. 110.
[495] Timon Screech, *The Lens Within the Heart*, p. 82.

constitute a real threat to them. It is thus reasonable to conclude that it aimed to satisfy the curiosity of the general public concerning the mechanical workings of clocks. The fact that the book proved to be quite popular suggests that there were enough amateurs who had at least some basic knowledge of mechanical devices, and who were eager to learn not only about what clocks did but also how they worked.

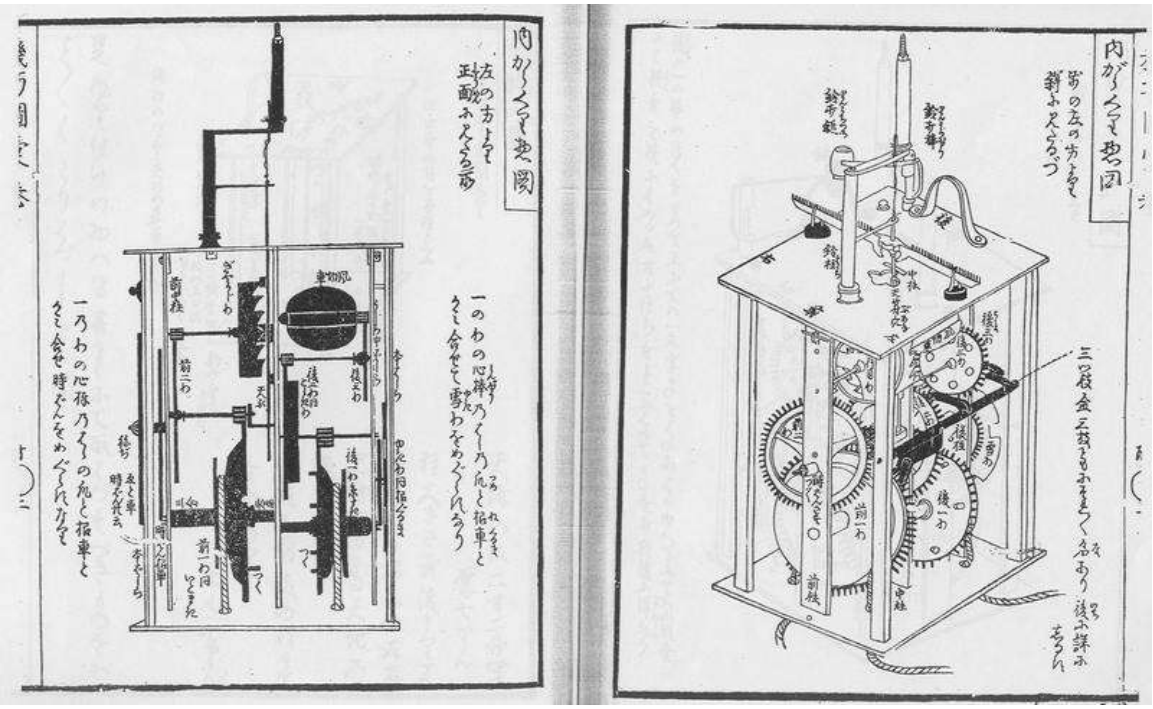

Image 14. ***Illustrated Manual of Curious Machines*****.**

The book targets educational amateurs who are interested in technology but prefer to reconstruct the device virtually, by following the descriptions and the images in the book.

The claim that *Illustrated Manual of Curious Machines* was disclosing the secrets of the clock-making profession derives from a common but misleading hypothesis, that the clocks were seen as something mysterious. Their mystery allegedly sprang up from the fact that the index hand of the device was set in motion by an internal and hidden mechanism, which worked

privately, not allowing anybody to uncover its secrets.[496] As appealing as this hypothesis appears, it becomes implausible once we consider the actual design of Edo-period clocks. It is hard to believe that clock was seen as mysterious because of its "secret" activity, since Japanese clock-masters tried their best to emphasize this movement by intentionally making the inner mechanism visible. In the case of four-legged tower (pedestal) clocks, the weights were exposed to view. Other tower clocks were sometimes left open in a way that showed not only the dial but also the moving balance. In some cases, we even see the moving parts of the mechanism brought to the front of the clock and a pendulum swinging in front of the dial. Pillow clocks were often confined to glass cases that made visible the pendulum and the escapement placed on the external side of the back wall, and provided a side-view of the mechanism, because the side-walls were usually removed. This common design element shows that the visibility of the mechanism was an important feature of clocks. Evidence for this is found in the *Illustrated Manual of Curious Machines*, where the author pointed out that *shaku* clocks had a glass window on their upper side "through which one looks at the movement of the balance."[497] Seeing these characteristics of the clocks, we can conclude that even though there is some truth to the claim that fascination with the clock was caused by the movement of the mechanism, this movement was not perceived as secret or mysterious, but rather as technologically sophisticated and ingenious.

[496] Screech, Timon, "Clock Metaphors in Edo Period," in *Japan Quarterly* (Oct-Dec. 1996), pp. 66-75. Screech writes : *"The workings of clocks provided a metaphor for secret activity, or even surreptitious machinations. Clocks ran on privately and internally in a way that no amount of staring at their outsides could ever fathom."* p. 66.
[497] Hosokawa Yorinao, *Kikōzui*, p. 195.

The *Illustrated Manual of Curious Machines*, motivated others to record, describe, and depict the internal structure of the clock.[498] The author of the *Illustrations of Timepieces*[499] certainly seem to borrow some of Hosokawa Honzō's images, but being drawn mostly to the pictures of gears and pins, he only rarely mentions any technical information, not even reaching the level of details in *Illustrated Manual of Curious Machines*. Seeing this indifference to the practical details necessary to actually build this kind of device, paired with the painstakingly detailed (yet somewhat amateurish) execution of illustrations, one cannot but get the impression that it was the joy of investigating the structure, of identifying the parts that make clock function that motivated the author to produce this manuscript. Through the investigation, and then by finally copying of the pictures from *Illustrated Manual of Curious Machines* the author was virtually building a clock on his own.

[498] See for example *Tokei Seisaku sho* 時計製作書 (Manual for making clocks), Tōhoku University Kano Archive; *Tokei zatō no zu* 時圭座等之図 (Illustrations of Clock Positioning), Kojū Bunko Archive; *Tokei zu kai* 時計図解 (Illustrated explanation of clocks), National Diet Library Archive. It interesting to note that all of the above are written by anonymous authors, undated, and don't even appear in the *Union Catalog of Early Japanese Books*. Another anonymous work *Tokei zu* 時計図 (Illustrations of Timepieces) preserved in Tokyo National Museum is the only one of the genre that appears in the catalog.

[499] Anonymous, *Tokei zu.*

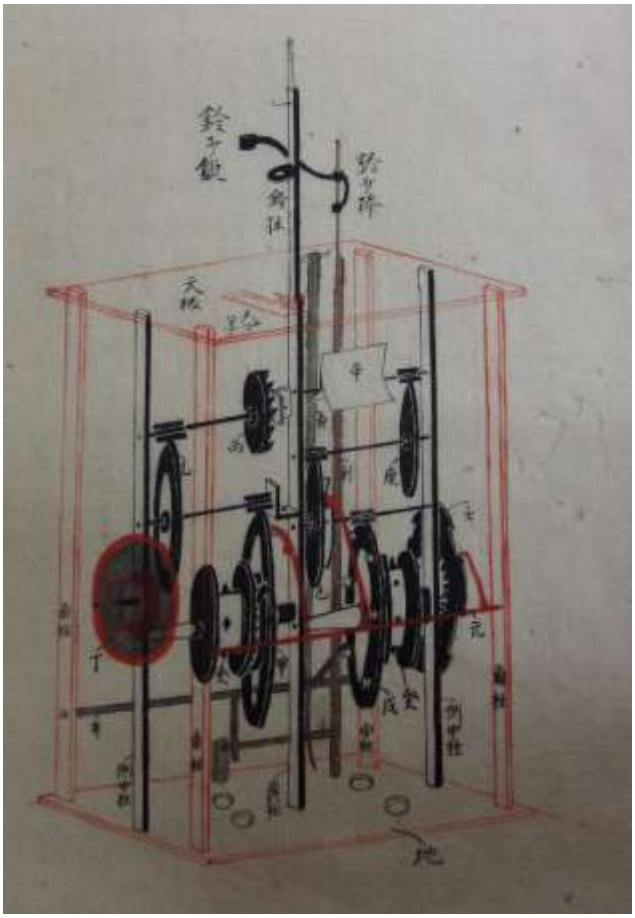

Image 15. *Illustration of Timepieces.* Tokyo National Museum Archive.

Note the similarity of this black-and-red image to the image in *Illustrated Manual of Curious Machines*.

The interest in the inner mechanism could also be seen in the reports of VOC employees in Japan. Martha Chaiklin, who investigated these reports, tells us about occasions at which Japanese officials borrowed clocks from the Dutch and later returned them in pieces.[500] Chaiklin interprets this as attempts by Japanese artisans to learn the art of clock-making. However, as seen in the previous sections, Japanese clock masters were quite accustomed with dealing with Western clocks, so it is doubtful that they were not able to reassemble such clocks, even if they encountered a somewhat different design. It is more likely that these incidents involved amateurs,

[500] Chaiklin, *Cultural Commerce and Dutch Commercial Culture*, p. 94. Chaiklin also mentions Japanese asking the Dutch for illustrated books about watch-making, and even for the tools necessary to construct them.

which would point to the fact that interest in clock mechanics was not confined to professionals who sought to utilize their knowledge.

Amateurs were driven by neither a profit nor a childlike fascination with the mysterious "inside". Rather, they were attracted by the exquisite product of human skill and ingenuity — mechanical motion. It was not only the product of mechanical motion, such as an alarm clock or the life-like motion of an automata, it was the mechanical structure itself that fascinated educated amateurs. And the ability to comprehend the complicated structure and the workings of mechanical devices was considered to be a sign of insightfulness, sophistication and ability to grasp complex matters.

Mechanical Universe

Yet understanding the machine sometimes had even deeper meaning. It was not the machine itself that needed to be understood; the machine was also a window to larger and more important things. This was certainly the case with Hazama Shigetomi, the astronomer who invented the *Suspended Swinging Disk* pendulum clock. For him, the pendulum was not only the means to produce miniscule time-units of constant length, but it was also a concrete manifestation of natural principles. In a small booklet titled *A Detailed Treatise on the Pendulum*,[501] Shigetomi recorded his thoughts about the working of this device. First he described a particular experiment he performed in order to learn the qualities of the pendulum. He made five pendulums of different heights and let them swing freely, counting the number of swings. He then concluded that the motion of the pendulum was determined by the proportion

[501] *Suikyūseigi* 垂球精義, 文化元 (1804), Gakushiin Archive.

between the length of its rod and the weight of its bob.[502] So far, this experiment testifies to an attempt to understand the mechanics of the pendulum. But Shigetomi went further and claimed that the regularity he discovered in the motion of the pendulum in fact reflects a general principle of nature:

> All this is due to the proportional relation of weights, and since this constant is [embedded] in natural regularities,[503] it does not allow even the smallest derivation. If one considers this carefully, one will surely learn the subtle details of this principle. Consequently, **one can use the pendulum to explore the natural regularities and to demonstrate these clear matters**.[504]

The pendulum here is not only set the mechanism of the clock in motion, it also reflected the movement of the universe since, in Shigetomi's words, both were based on the same natural regularity. He writes:

> Namely, **since the movement of the pendulum depends on the proportional relation of its weight, if we fathom the regularity of the pendulum, the regularity behind the natural movement of the heavens will instantaneously become clear**, as if a lamp was lit in the midst of total darkness.[505]

He then went on to say:

> [T]he celestial bodies have weight, **and all the bodies that have weight follow the same principle as the one behind the [movement of the] pendulum**[506]

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[502] Some may note that this proportion does not really exist, and that Shigetomi was mistaken in his assumptions. However, my purpose here is not to evaluate the result of his experiment but rather to follow the development of his thought.

[503] The Japanese expression is 天理自然の数. There is a long debate concerning the actual meaning of 自然 in Chinese and Japanese natural history and philosophy, and many rightly argue that prior to the modern period it did not bear the same range of meanings, as did Western notion of "nature". The meaning of the words, however, does not change instentaniously, and could not have suddenly appeared in the Meiji period. In his "The Names of Nature", Federico Marcon argues that the Japanese word 自然 began acquiring the meaning of "nature" through the redefinition of terms that was the result of encounter with the Western natural history in the first several decades of the nineteenth century. I will argue that this text too exhibits meaning close to the Western "nature". Looking at the context and the implication of the whole text, Shigetomi's claims that "proportions" and "regularities" of weight and motion are universally valid, cannot be changed under any circustances, and can be defined in numbers — all these indicate that *his* meaning of 天理自然の数 is somewhat close to Western "laws of nature".

[504] Hazama Shigetomi 間重富, *Suikyūseigi* 垂球精義 (*Detailed Exposition of Suspended Disk*) 文化元 (1804), Gakushiin Archive.

[505] Ibid.

[506] Ibid.

For Shigetomi, this comparison was not only a metaphor, but also a device that helped him visualize and thereby conceptualize the movement of the stars in the universe. He wrote:

> The celestial bodies are [made] entirely of *qi*. The sun, being at the center of the universe, is situated at the heart of the *yang qi*. […]The planets float in the universe, each one in a different layer. The weight of the planets and that of the *qi* counterbalance each other, causing the planets to be situated exactly at the place they should be**. In order to measure this regularity, nothing is better than the pendulum. Suppose the sun is the pivot from which the pendulum is suspended, and that a pendulum rod one *shaku* long is like the diameter of the first layer of the universe. If we take the weight of the pendulum to be the weight of the *qi* of the first layer in the universe, this will indicate where a body of that weight should be situated**. Next, a second pendulum, with a two *shaku* long rod will represent the diameter of the second layer of the universe. The weight of this pendulum will be like the weight of the *qi* on the second layer. The third and forth pendulums are, accordingly, like the third and the fourth layers of the universe, and the pendulum rods will represent the diameters of those layers.[507]
>
> When we look at the proportional relation of the heavenly *qi*, the closer a heavenly layer is to the fire of the sun, the lighter its *qi* is. Therefore, the planet on this layer will be light as well (there is no relation to the size [of the planet], only to its weight). The *qi* of a layer that is far from the sun is heavy, and hence a planet in this layer will be heavy too. For this reason, the rotation of a planet close to the sun, such as Mercury, is quick, whereas the rotation of planets distant from the sun, like Saturn, is slow. **The principle behind this proportion between the slow and quick [movements] and the distance of the planets from the sun is exactly the same principle that governs the [motion of the] pendulum[508]**.

As we can see, Shigetomi uses the visual metaphor of the pendulum to perform a kind of thought experiment that will help him arrive at a theory of planetary motion. He finds regularity in pendulum motion, and attempts to extrapolate from this regularity in order to understand the position and the motion of planets. His investigation of the pendulum is therefore not only an investigation of a mechanism, but a means to the much deeper and broader understanding of *the* mechanism, the mechanism that governs the world, where things are "exactly in the place they are supposed to be."[509]

[507] Ibid.
[508] Ibid.
[509] Ibid.

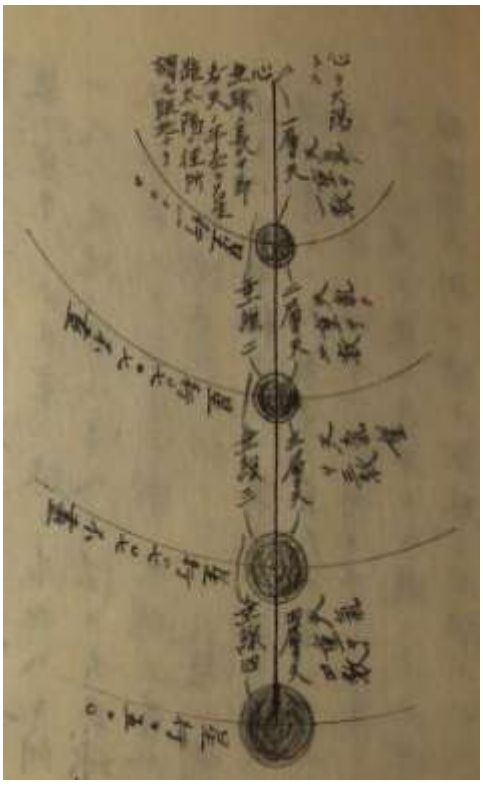

Image 16. *Detailed Treatise on the Pendulum*, Gakushūin Archive.

In this sketch Hazama Shigetomi depicts planets as a set of pendulums suspended from the sun (the upper point, indicated here as "the heart" or "the center"). Using his understanding of the pendulum, Shigetomi was trying to arrive to proportional distances between different planets, their weight and the speed of their motion.

Hazama Shigetomi was, of course, a professional astronomer, and it is not at all surprising that he used insights from his practical experience with mechanical devices and carried those insights over to the theoretical realm of planetary motion. Yet the idea that mechanical clocks are only one variant of a broader set of natural "mechanisms", and that both clocks and the universe are governed by the same regularities was not confined to the professional realm alone. One of the strongest pieces of evidence for the prevalence of a kind of mechanical view, comes from a rather unexpected source — Buddhist doctrine. Already during his studies at the Nichiren sect Myōyō temple in the end of the eighteenth century, Fumon Entsū[510] was troubled by the inconsistency between Buddhist cosmology and the increasingly popular Western astronomical theory. At that time, the acquaintance with Western sciences was

[510] 普門円通 (1755-1834)

no longer limited to a small group of professionals. Popular books, such as Shiba Kōkan's[511] *Dutch Explanation of Heavens,*[512] not only propagated new models of heavens and celestial motion but also supported their views with rather convincing pictorial representations and models that could conveniently explain observational data.

Entsū himself was not swayed by Western theories, sticking to the view that only spiritual wisdom of Buddhist doctrine could have had an insight into a real structure of the universe. But he could not fail to notice that books propagating Western theory were simply too convincing. "Convincing" for Entsū did not necessarily meant "true," however. Therefore, instead of fighting Western cosmology on ideological grounds, or trying to convince others to accept the superiority of Buddhist doctrine, Entsū decided to adopt a different strategy, embracing the very methods and characteristics that made Western theory "convincing."

First, Entsū constructed his own Buddhist universe in his *Book of Astronomical Phenomena in Buddhist Countries.*[513] Entsū's universe was very much based on the traditional Buddhist cosmology: a central, trapezoid-shaped mount Sumeru (Shumisen in Japanese) surrounded by additional ridges of mountains, seas and lands stretching in four directions on an immense plain. Rejecting the theories of a spherical and geokinetic earth, Entsū nevertheless accepted the depiction of world geography in Western maps, with a small provision that the known continents are nothing but a group of islands that lay in some distance from Mt. Sumeru.

His justification of this cosmology, however, was based on the contemporaneous astronomical methods of mathematical calculations, observational data, and experiments. Thus,

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[511] 司馬 江漢 (1737-1818)

[512] *Oranda Tensetsu* 和蘭天説, 寛政七 (1795) Waseda University Online Collection of Chinese and Japanese Classics (http://archive.wul.waseda.ac.jp/kosho/ni05/ni05_00777/ni05_00777.html last accessed April 2012).

[513] *Bukkoku rekishō hen* 仏国暦象編, 文化七 (1810). Tohoku University Kano Archive. This treatise is available in many archives and collections across Japan.

for example, he provided different interpretations of experiments proving the sphericity of the earth and criticized existing calculations of the earth's mass.[514] It is true that for him the validity of the Buddhist cosmology derived from his belief that the truth about universe could be perceived only through divine vision, but his justification for the exact parameters of his universe, as well as the criticism of alternative theories, were supposed to be based on astronomical analysis. Criticizing the outcome of Western astronomical theory, therefore, Entsū wholeheartedly accepted the method employed by official astronomers of his time.[515]

Moreover, it was not only a matter of calculations or observations. Entsū accepted the very premise of Western cosmography — that the ability to map, depict and visually represent cosmological ideas testified to the validity of cosmological model. Namely, in his opinion, the power of a Western cosmology of a spherical (not to mention heliocentric) universe lay in the ability to convincingly depict it in maps, celestial and terrestrial globes, and an armillary sphere. The solution to this problem seemed obvious to him — to create a realistic depiction of the Buddhist world that would correspond to both mathematical data and observed experience. For Entsū, a model, *gi*, 'is a "form", [which] "represents" and "confirms [something]." And his aim was to build a 'model that represents and conforms to the world of Mount Sumeru,'[516] which would convince people of the validity of the Buddhist cosmology.

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[514] In his excellent dissertation titled "Vision and Reality: Buddhist Cosmography in Nineteenth Century Japan," Ph.D.. Dissertation (Stanford University, 1997), Okada Masahiko provides an excellent analysis of Entsū's work.

[515] In his *History of Japanese Astronomy*, Shigeru Nakayama depicted Entsū as a representative of dogmatic forces holding onto the traditional theory, namely, a representative of pre-paradigm shift faction. (Shigeru Nakayama, *History of Japanese Astronomy* (Cambridge, MA: Harvard University Press, 1969), pp. 210-213). Nevertheless, his acceptance of existing methods of astronomical practice testifies to the fact that he was very much in line with the leading scholars of his time in terms of his approach to scientific investigation. We no longer discuss scientific developments in terms of paradigmatic shifts, but if we were to do so today, it would be fair to say that Entsū's example shows that differentiation along paradigmatic lines should not be based on theoretical differences but rather on practical approaches and underlying assumptions.

[516] Fumon Entsū, *Shumisengi mei narabini jo wakai* 須弥山儀銘並序和解 (Japanese explanation of model of Mt. Sumeru), 文化十 (1813), Tohoku University Kano Archive.

Building a clockwork universe was not easy and initially Entsū's model was only conceptual and pictorial, but in late eighteen forties the opportunity presented itself when he turned to the famous mechanical artists Tanaka Hisashige for help.[517] Making sure to preserve the physical proportions of the Mount Sumeru world and to accommodate the observed phenomena, Tanaka Hisashige created a working clock-work Buddhist Universe. True to Entsū's Buddhist cosmology, the *Model of Sumeru World*[518] was a mechanical planetarium where the sun and the moon circled above the trapezoid mountain painted in four colors to represent different seasons. This device provided the viewer with the position of the sun, the moon, information about tides, and the moon's age, being reminiscent in its functions to an armillary sphere. On its front, there was a mechanical clock, which served to testify that the whole device was actually working and was in accordance with the observable world.

[517] Seiko Horological Institute lists their *Model of Sumeru World* as dating back to 1847. Scholars agree that Tanaka Hisashige worked on *Model of Sumeru World* before his creation of the famous *Myriad Years Clock* in 1850.
[518] *Shumisengi* 須弥山儀.



Image 16. *The Model of Sumeru World (Shumisengi),* Seiko Institute of Horology (author's photograph).

The trapezoid structure is Mount Sumeru, each side of which is colored according to the four seasons (Summer is gold, Autumn is red, Winter is blue and Spring is green). The dial on top of the structure indicates the twenty-four mini solar seasons (*sekki* 節気). The disk hovering above the mountain is marked with the twelve "seasonal months" (*choku* 直), which were defined not by the waxing and waning of the moon, but by the annual rotation of the Big Dipper. The Small balls representing the motion of the sun (painted gold) and the moon (painted silver, below the disk in this picture) are attached by wires to the disk at the top of the model, circling above the *Sumeru World*. The characters on the outside edge of the bottom indicate the twenty eight constellations ("lodges" *shuku* 宿) of Chinese astronomy.

For Entsū, the clockwork mechanism was not a mere means to set in motion his miniature Sumeru World, it was a proof of model's validity. Traveling through various domains, Entsū

lectured about his observationally supported and mathematically defined Sumeru World, and accompanied his lectures with demonstrations of one of the *Models* he ended up ordering.[519] According to his rationale, if it was mechanically possible, then it must be possible in reality.

Not everybody was swayed by Entsū's presentations of his model. Although some professional astronomers famously refuted his theory,[520] others thought that engagement in any kind of discourse with Entsū was simply beneath them. Nor did the Buddhist establishment embrace his theory, and he had to change sectarian affiliation due to internal disputes. Nevertheless, his mechanical rationale resonated with his audience, and he was successful in drawing a large number of followers, creating the whole *Indian Calendar*[521] movement that attempted to construct an actual calendar based on Sumeru cosmography.

Entsū's success also inspired one of his followers, a monk from the Jōdoshinshu Honganji school of Buddhism, Sada Kaiseki [522] to utilize more mechanical models to support his preaching about Buddhist doctrine. With the help of none other than Tanaka Hisashige, Sada Kaiseki created a *Model of Both Observed and Real Phenomena*[523] to compensate for the large scale *The Model of Sumeru World*, which didn't allow seeing the earth as it is known from world maps. Kaiseki's model showed only the part where the earth was immersed in the vast sea surrounding Mount Sumeru, and it's relative position to the sun. For him, "observed" was

[519] According to Sawara Taira, there are seven surviving *Shumisegi* in Japan. Sawada, Taira, "Shumisengi monogatari [The Story of the Syumi-sen-gi]", in Wadokei [Journal of the Wadokei-Gakkai], Otsu: Wadokei Gakkai, num. 41, January 2007, pp. 17-23

[520] See, for example, Inō Tadataka

[521] *Bonreki* 梵暦. Written in this character "Indian" means "related to Buddhism".

[522] 佐田介石(1818-1882).

[523] *Shijitsutōshōgi* 視実等象儀. Catalog of Tokyo Science Museum dates the model to 1850. Oda Sachiko 小田幸子 and Sasaki Katsuhiro 佐々木勝浩, *Zuroku wadokei* 図録和時計 (*Illustrated Catalog of Japanese Clocks*) (Tokyo: Tokyo Science Museum, 1981).

cosmography supported by contemporaneous astronomical theory,[524] while "real" was a Buddhist world. Consequently, the device explained how a model of scholarly astronomical cosmography could be fit into a larger scheme of the Buddhist Universe. The *Model of Both Observed and Real Phenomena* positioned the audience at an objective, outside point of view, from which it was possible to observe the heavenly rotations relevant to human world but also the general motion of the sun and the moon above Mt Sumeru.[525]

The validity of both models of the Buddhist universe was implied by their mechanical structure, suggesting that mechanical possibility is indicative of a the "real" structure. Yet the fact that both models incorporated within them a real working clock, tells us something more — the model had to abide by the physical rules guiding and enabling the motion of mechanical clock. The clock, thus, became a symbol of the regularities in the natural world, a working microcosm of the universe.

Conclusion

So why clocks? Clocks may have been a symbol of status, but there must have also been a reason for them to become one. And this reason was the fact that clocks were *machine*s. It was neither the timekeeping *functions* of the clock, nor the *result* of efficiency they promised, nor their exotic *origin*, but rather their very *structure* that made them attractive.

But "machine" had different meanings in different periods of time throughout the Edo period. The immediate impression clocks made upon their introduction to Japan in the sixteenth century was that they function *on their own*, without any humans operating them directly. Surely,

[524] The astronomy practiced in Japan at that time was heavily based on Western astronomical theory and practice but incorporated several major elements of Chinese astronomy. Moreover, Entsū objected not only to the geokinetic view but also the mere idea that the world is spherical, and hence rejected Chinese astronomical tradition as well.
[525] Takehiko Hashimoto, "Hisashige Tanaka and His Myriad Year Clock" in *Historical Essays on Japanese Technology*, (Tokyo: Collection UTCP, 2009), pp. 42-44.

they were also foreign, but at that time there were many "foreign" objects imported from Europe, and most of them didn't evoke similar reactions. Moreover, the clocks were quickly stripped of their "foreign" attributes, but their appeal as machines, as automated devices that worked on their own, remained.

Machines were still considered to be a novelty at the end of the seventeenth and the beginning of the eighteenth century. Marking the beginning of mechanical fashion, clockwork devices were considered to be the sophisticated and exciting. A recent novelty, they symbolized the new culturally sophisticated era and marked the difference between the past and the present, between the sophisticated Edoites and backward country bumpkins.

What marked the difference between the old and the new, between the sophisticated and backwards, was precisely the attitude toward mechanism. In the beginning of the eighteenth century machines were not appreciated as a mystery or magic but as a form of art. Automata makers' objective was to convince the audience that the movement of the puppet was a product of his artful mechanical design and *not* clever machination of his hands. The invention of more and more automata was a testimony of the artist's ingenuity, his way to show what he could produce with his mechanical skills. Humanoid automata were admired not because somebody mistook them for a real human being, but just because everybody knew it was a machine that produced human-like motion. Clocks were admired not because they mysteriously kept the time, but because time measurement was produced with moving gears, which were purposefully left exposed for all to see.

Towards the end of the eighteenth century, it was no longer enough to appreciate the movement of an exquisite automaton or a clock. Those who considered themselves sophisticated enough, wanted to know how were those built. The literature that described the inner structure of

clocks and automata could not have taught anyone how to build a mechanical structure, but it gave one an illusion of familiarity with mechanical motion. Understanding mechanics meant understanding how things worked beyond what was apparent to the naked eye.

In the nineteenth century, mechanical movement was no longer just a means for producing entertainment. It represented certain regularities of motion, it abided by the laws of proportionality and signified the limits of what is physically possible. And the conclusion was, that if a model is mechanically possible, then the thing it represented must be real. As the ultimate machine, clocks and watches didn't just point out human time — the time they showed was tied to the universal, cosmic time.

Chapter 6: Inconvenient Time

Introduction

The notion of mean time, as well as the new conception of time as universal and independent of human activity, were just some of the factors that preoccupied Shibukawa Kagesuke when he was devising the final calendrical reform of the Tokugawa period — the Tempō reform.[526] While preserving the variable hours, Kagesuke's calculations of the exact length of the hours in each season took into account the non-uniform nature of earth's rotations. Through the incorporation of astronomical knowledge he found in Lalande's *Astronomie*, Kagesuke seems to have successfully employed the up-to-date Western astronomical theory while still serving the temporal structures of Tokugawa society.

But the times were changing. Kagesuke's success didn't find much appreciation and his system was short-lived, succumbing to the forces of cultural priorities. The dawn of the new era that began already before the Meiji period marked the countdown to the eventual doom of both the existing calendrical system and the system of variable hours. Six years into the Meiji period, in 1873, another calendrical reform, based entirely on the Gregorian solar calendar, disposed of the old ways of counting, measuring and viewing the years, months, days and hours.

Why was this reform carried out, if things worked well up until now? Even if there were unavoidable imperfections of the calendar before, Shibukawa Kagesuke seemed to have made substantial improvements by incorporating Western astronomical notions with the local demand for luni-solar calendar and variable hours. How come suddenly this system came to be seen as dispensable and even undesirable? How come the existing time came to be labeled as

[526] Tempō Calendar (天保暦) was implemented on the first day of the year Tempō 15 (1844).

"inconvenient"? Moreover, what were the processes by which the new, foreign and Western time came to be seen as logical, advantageous and convenient? The answer to these questions lies in the developments that occurred in the several decades before the beginning of the Meiji period. Looking at the various justifications for the calendrical reform of the 1873 we find that rather than creating a revolution, the reformers only affirmed the already existing practice of using Western watches and Western temporal convention, which were understood through the process of translation between foreign convention and the familiar habits of timekeeping.

Creating Inconvenience

Sprouts of initiatives to revolutionize the calendar can be seen already in the end of the eighteenth century. Perhaps unsurprisingly, it was the admirer of the West, Honda Toshiaki, who first started musing with the idea of adopting the Western calendar instead of the existing one. In his *Tales of the West*,[527] Toshiaki bestowed praises on the Western knowledge of the three fields most important to him— astronomy, geography and navigation,[528] and suggested adopting the Western calendar, which was based on knowledge accumulated in these fields. His description of this preeminent Western calendar, however, strikes the reader as somewhat ill informed: not only that he claimed that there were no big and small months, but he also did not distinguish between the Julian and the Gregorian calendars and attributed the beginning of Western year count to the reign of a Roman Emperor.[529] The passage about the calendar was not exceptional in its inadequate reflection of the actual state of affairs in Europe. In some cases he was plainly mistaken, such as for example in his claim that "the ruler of Rome, the capital of Italy is the

[527] Honda Toshiaki 本多利明, *Seiiki monogatari* 西域物語 (*Tales of the West*), 寛政十 (1789). Reprinted in *Nihon Shisō Taikei* 日本思想大系, vol. 44 (Tokyo: Iwanami Shoten, 1970), pp. 87-162.
[528] The combination of these three words (天文、地理、渡海) repeats on every page of the first volume of *The Tales of the West*, urging in different ways to "develop" (開く) these fields.
[529] Toshiaki does not really specify which emperor. *The Tales of the West*, Nihon Shisō Taikei, vol. 44 p. 106-107.

emperor of the whole Europe"[530]; in numerous other cases he describes thousands of ships filled with goods cramming the ports, universities that only promote the talented and government institutions that promote justices, and officials who are attuned to the needs of the people. In his description, all European countries exhibit nothing but excellence, efficiency and foresight. Consequently, *The Tales of the West* reads more like a utopia, in which, rather than providing an adequate description of European institutions, Toshiaki used a rather patchy knowledge about the West in order to convey his concerns about his own society.[531] Taking Toshiaki's description of the Western calendar as a critical prism, we understand what were the aspects that troubled him the most in the existing system — the disparity between the solar seasons (the *sekki*) and the lunar months, the fact that the arrangement of the calendar varied from year to year, and most of all, the existence of auspicious and inauspicious indicators.

Toshiaki was not alone with his criticism. Just a couple of years after the publication of *The Tales of the West*, we see another utopian calendar. Written in 1801 by a Confucian scholar Nakai Riken[532], this calendar indicated its utopian nature in its very title. Roughly translated as "A Calendar Invented by the Yellow Emperor[533] in His Dream Country,"[534] Riken's calendar introduces a vision of a perfect system. Rather than advocating the adoption of the Western calendar, Riken created a hybrid calendar of his own . While preserving the variable hours, and

[530] *Seiiki momogatari*, Nihon Shiso Taikei, vol 44. p. 98. It is not clear what was the source of this mistake. One possibility is that Toshiaki was confused by the "Holy Roman Empire", and another could be influenced by Jesuit sources from China were the Pope was presented as the strongest person in Europe. In any case, this kind of mistakes point to the fact that Toshiaki was more guided by his own pressupositions about what Europe *should* be, rather than reliable information from Europe.

[531] In her excellent article, Annik Horiuchi treats several of Toshiaki's writings as utopian. "Honda Toshiaki (1743-1820) ou l'Occident comme utopie" in F. Girard, A. Horiuchi, M. Macé (dir. & éd.), *Repenser l'ordre, repenser l'héritage: Paysage intellectuel du Japon (XVIIe -XIXe siècles)* (Droz, 2002), pp. 411-448.

[532] 中井履軒 (1732-1817).

[533] A legendary Chinese sage who, according to the legend, supposedly ruled in the third millennium BCE, wisely established social structures and formulated the principles of cosmology, medicine, astronomy, agriculture, etc.

[534] *Kashoreki* 華胥暦 cited in Okada Yoshirō 岡田芳郎, *Meiji kaireki: "toki" no bunmei kaika* 明治改暦：「時」の分明開化 [*The Modernization of the Calendar*] (Tokyo: Taishukan Shoten, 1994), pp. 39-40.

indicating the position of the moon, Riken based the calculation on the solar motion alone, dividing his 360-day year into four equal seasons.[535] With its balanced and equal divisions, more than anything else Riken's system looks like a straightforward demand for regularity.

What strikes the reader the most about these and other proposed calendars is the extremely vicious language used to denounce "the middle section," namely, the auspicious and inauspicious indicators[536] in the calendar. Honda Toshiaki entitles divination with the colorful adjective of *idiocy*,[537] while Riken denounces this aspect of the calendar by repeating the words of his older brother Nakai Takeyama,[538] who referred to indicators as "unreasonable fables[539] that greatly damage the public, and easily mislead the ignorant people of this realm, making it hard to enlighten them".[540] Writing in 1789, in response to Matsudaira Sadanobu's query about government, economics and society, Takeyama did not necessarily advocate reforming the calendar and certainly did not model his ideas on the West, but rather pointed his criticism at the social aspects he deemed to be damaging. This attitude towards divination seemed to become more and more widespread among scholars, and Takeyama's words resonated in many writings after him. In an actual proposal to reform the calendar in the first years of the Meiji period, Tsukamoto Aketake[541] harshly criticized the existing system saying that "especially […] the middle part is mostly composed of baseless fables that impede the advancement of people's

[535] In Riken's calendar a year is 366 days, spring lasting 93 days and the three other seasons lasting 91 days each. Okada Yoshirō, *Meiji kairek*i, pp. 39-40.
[536] *Rekichū* 暦柱.
[537] *Ahō* 阿房 *Seiiki monogatari, Nihon Shisō Taikei*, vol. 44, p. 109.
[538] 中井竹山 (1730-1804).
[539] *Bōtan* 妄誕.
[540] *Sōbōkigen* 草茅危言 (*Dangerous Words of Grass and Straw*). Cited in Okada Yoshirō, *Meiji kairek*i, p.37.
[541] 塚本明毅 (1833-1885).

knowledge."[542] An identical phrase is also found in the imperial restrict that declared the reform of 1873, stating in more elegant wording that the middle part of the calendar is "baseless fables that impede the advancement of human wisdom."[543] The rhetoric of stupidity versus human wisdom turned out to be highly contagious.

As we have seen earlier, the potential for calendrical reform was always present in both Chinese and Japanese history. No calendar could be perfect, and it was only a matter of a political decision as to when to point out the inconsistencies in calculations of the previous system. In the discussions leading to the Meiji reform, however, the criticism was not pointed at inadequate calculations, but rather to the very relationship of people with certain aspects of the existing calendar, specifically the divinational practices. The reformers did not only want to reform the calendar, they also wanted to reform humanity, the people themselves.

The concern for "the people" also seems to be a reason behind (or an excuse for) additional criticism of the calendar. One of the major complaints of early nineteenth century scholars who focused on calendrical reform, was that the existing calendrical system was just too complicated, making it impossible for "the people" to calculate the dates on their own. As mentioned in previous chapters, the luni-solar calendar that required consideration of both solar and lunar rotations created a system where months were not necessarily aligned with seasons (*sekki*), and where the sequence of big and small months changed from year to year. The compilation of the calendar required the ingenuity of astronomers who found ways to reconcile the seemingly incompatible cycles of the moon and the sun and "granted the seasons"[544] to the

[542] "率ネ妄誕不稽ニ属シ民知ノ開達ヲ妨ルモノ少シトセス" in *Tsukamoto Aketake Kengi* 塚本明毅建議 (Tsukamoto Aketake Proposal) , cited in full in Okada Yoshirō, *Meiji kaireki*, p. 126-128.
[543] "率ネ妄誕無稽ニ属シ人智ノ開達ヲ妨ルモノ少シトセス" in *Shōsho* 詔書 (Imperial Restrict), cited in Okada Yoshirō, *Meiji kaireki*, p. 117.
[544] I here borrow Nathan Sivin's translation of the famous thirteenth-century Chinese calendar *Shoushi li* 授時曆.

people.[545] Contrary to that, the late Tokugawa reformers sought simplicity. According to Yamagata Bantō,[546] who similarly to Honda Toshiaki looked to the West in his vision of progressive society, the beauty of the Western calendar lay in the fact that "the seasons and the big and small [months] are known even to girls and infants."[547] But surely enough, "girls and infants" were not the primary concern of reformers. In 1872, in a concrete proposal to reform the calendar Ichikawa Saigū[548] explained the benefits he believed the new calendar would bring:

> [It is] extremely convenient and extremely clear; a beautiful calendar that won't change in myriads of generations. In times of [extensive] international relations, it will show the world the unprecedented and uninterrupted imperial line [of Japan]; it will be enormously useful to navigation, and it will enable us to easily make a nautical almanac good for several years ahead; it will be possible to schedule with somebody an appointment that will happen in several decades, and know the eclipses that will happen hundreds of years from now. There is no inconvenient intercalary month, and once you get to know the number of days in a year there is no nuisance of remembering it each year.[549]

Passages like this make it clear that in reformers' opinion, the main problem with the existing system paradoxically lay in the fact that it was necessary. If previously intellectuals in both China and Japan praised the calendar as a pinnacle of human achievement,[550] as a means that provided people with useful knowledge, in the middle of the nineteenth century, these very features came to be seen as an impediment. It was neither a matter of improvement, nor of a sudden discovery of the deficiency of the previous calendar— both the achievements and deficiencies were always, present; it is the associations of specific features with broader cultural norms that made something an inconvenience. For mid-nineteenth century thinkers, the very fact that calendar brought order to the complex celestial rotations made it an obstacle — it was

[545] In the language of 13th century Chinese calendar mentioned earlier in this study.
[546] 山片蟠桃 (1748-1821).
[547] Yamagata Bantō 山片蟠桃, *Yume no shiro* 夢之代 (The Dream Age) 享和二 (1802), cited in Okada Yoshirō, *Meiji kaireki*, p. 41.
[548] 市川齋宮 (1818-1899)
[549] *Rekihō gian* 暦法議案 (Proposal Concerning Calendrical Method). Cited in Okada Yoshirō, *Meiji kaireki*, p. 73.
[550] On the role of the calendars in human lives see chapter 1; on calendrical reforms see chapter 4.

simply too essential and indispensible, forcing the people into a subordinate position of dependency. In the minds of these thinkers, the "enlightenment of the people" meant simplifying the system to the point that they do not need the calendar at all. What was previously perceived as blessing came to be seen as an "inconvenience."

The rhetoric of *inconvenience*[551] was present in virtually every mid-nineteenth century text that dealt with the (possible) reform. Ichikawa Saigū wrote that "our present system is based on the moon, and makes it easy to follow the phases of the moon, but for the distribution of months in one year it is very inconvenient." In the new system that he suggests however, "months are aligned with the seasons, and it will be very useful to agriculture."[552] In an address to the government, another reformer stated that "because of the intercalary months, months do not match the *sekki* which is very inconvenient. There is a great damage to that. The people are used to this [system] and up until now they have not realized this enormous loss, but this day has come. We must change the calendrical system."[553] In Ichikawa's (and many other scholars') mind, it was the role of the intellectuals to tell "the people" what was convenient to them.

This rhetoric of enlightened usefulness, as opposed to ignorant inconvenience, culminates in the single most famous text about the Meiji calendrical reform — *The Speech on the Calendrical Reform*,[554] written by the leading "modernizer" of Japan, Fukuzawa Yukichi immediately after the new calendrical system was inaugurated.[555] Produced in a mere six hours one morning, according to the author, the several-pages long pamphlet became an instant hit. Fukuzawa Yukichi started it by praising the simplicity of the new Meiji calendrical system:

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[551] *Fuben* 不便.
[552] *Rekihō gian* 暦法議案 (Proposal Concerning Calendrical Method). Cited in Okada Yoshirō, *Meiji kaireki*, p. 74.
[553] 広川晴軒 (1803-1884). Cited in Okada Yoshirō, *Meiji kaireki*, pp. 79-80
[554] *Kairekiben* 改暦弁.
[555] 福沢諭吉 (1835-1801).

> In this system, the four seasons are the same each year with no difference in heat or cold. Every day and every month falls exactly on the same day as the year before. And if you want to plant your seeds or harvest the grain, you don't need to look into the calendar, if in the previous year *higan* was on the third month 21 day, then this year it will be exactly the same day.[556]

And later in the text he repeats his point: in the calendrical system based on lunar motion it is indispensible to look at the actual paper calendar in order to know the seasons, but the new system will enable to obviate the calendar altogether.[557] And similarly to previous authors, this urban scholar seems to know better what is good for the general population. He predicts that what he says "will at first appear to the unlearned people as surprising and inconvenient," but, he continues, "even thought the inconvenience of ignorant people is pitiful, I don't have the time to explain everything to them."[558] Rather than explaining the new system, therefore, Fukuzawa Yukichi preferred to shame people into accepting it. After all, nobody wanted to be associated with "uneducated and ignorant fools"[559] who dared to doubt the new system.

But Fukuzawa wasn't only speaking to the self-satisfying sense of enlightenment and progress. In the spirit of highly commercialized society of late-Tokugawa, early Meiji Japan, he was also addressing the common concern with finances. Talking about the previous, luni-solar calendar, he described the discrepancy between the solar year and the twelve lunar months as "missing days" and compared it with lost money.[560] No matter that this discrepancy was corrected by the intercalary month, so nothing was really "lost"; and no matter that the new solar calendrical system too had to deal with similar discrepancy between the length of the solar year (365 days, 5 hours, 48 minutes and 52 second) and the number of days in the calendrical year, so

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[556] Keiō Gijuku 慶應義塾 (Keio University) ed., *Fukuzawa Yukichi zenshū* 福沢諭吉全集 (Collected Works of Fukuzawa Yukichi), vol. 3 (Tokyo: Iwanami Shoten, 1969), p. 324.
[557] Ibid.
[558] Ibid.
[559] 無学文盲の馬鹿者なり. Ibid. p. 325.
[560] Ibid.

that one could similarly talk about "missing hours." Neither Fukuzawa Yukichi nor his readers were interested in the actual calculations. The new rhetoric of time=money was powerful to convince those who still have any doubts.[561]

In general, the new calendrical system was presented in a rather idealistic and perhaps purposefully naïve way. Even though all the writers complained about the "inconvenient" intercalary month, none was troubled by the existence of the leap day in the new system, and many simply "forgot" to mention it. When talking about the eternally repeating calendar, the authors omitted the fact that in the new system months did not necessarily match the days of the week. Many seemed to have a kind of idealistic expectation to have the same weather on the same days and months year after year. But these details did not matter, what mattered was the ideal of simplicity, usefulness, convenience and enlightenment.

There was one aspect, however, where none of the authors, not even Fukuzawa Yukichi, seemed to find it necessary to apply the rhetoric of enlightenment. In addition to abandoning the lunar rotation in favor of purely solar-based calendar, the new system also reformed the hours. Disregarding the amount of light and darkness in a day, the reform abandoned the variable hours in favor of twenty-four equal ones. Nevertheless, none of the authors seemed to find it necessary to explain why was this change necessary, nor even try to legitimize the change in the eyes of the public.

[561] Nishimoto Ikuko discusses in her article the introduction of "Time is Money" phrase into the Meiji educational system as a translation of European-language expression. (See Nishimoto Ikuko, "Teaching Punctuality: Inside and Outside the Primary School" in *The Birth of Tardiness*, published in *Japan Review*, n. 14, 2002, pp. 121-134). Nevertheless, even if the phrase did not exist in Japanese before the 1870s, the sense that time efficiency is important to economic success existed already in the beginning of the nineteenth century. See chapter 1.

Ichikawa Saigū just stated the fact: "one day is divided into 24 hours, each one is divided into 60 minutes, each one of which is divided into 60 seconds".[562] The official government notice also just stated the change:

> Up until now we divided the day into twelve hours according to the length of day and night. From now on we will rely on the hours of "jishingi", which divides the time of the day and night into 24 equal hours. From the hour of the rat until the hour of the horse, these will be the 12 hours of AM,[563] and the twelve hours after the [noon] hour of the horse will be called PM[564] …. Up until now we referred to the hours by the character, but from now on we will do it by the hour.[565]

And the imperial rescript that declared the reform didn't even mention the hours at all. In a rare instance, Tsukamoto Aketake claimed in his proposal that the previous system of hour counting was "inconvenient for all sort of things" but never really explained what all these things were, shifting the conversation to the easy denunciations of the "middle section" of auspicious and inauspicious indicators used in divination.[566]

Even Fukuzawa Yukichi suspended his rather venomous rhetoric in favor of direct explanation:

> In the West, the day is divided into 24 hours. Their hour is equal to the "old" Japanese half an hour. This half-hour is divided into 60 units, each of which is called a "minute" (*miniuto*). This minute is further divided into 60 seconds (*sekando*). This second is generally the same as one movement of a pulse. Now, the face of the clock is divided into 12, the small hand making this circle twice. The long hand revolves around the clock 12 times. Noon and midnight are the origin of the 12 hours, and at this time both hands come to this place together. From there they are gradually moving right, and when the short hand points to 1 o'clock, the long hand made the whole circle of 60 minutes and came back to the place of 12 hours, and from there it goes on its next round. While the short hand moves half way from 1 to 2, the long hand travels half of the clock face for 30 minutes, and comes to the place of the 6th hour. Therefore, when looking at the clock, first look at the place that the short hand points to, and then look at the place where the long hand points. For example, if the short hand points to the place between 9

[562] Cited in Okada Yoshirō, *Meiji kaireki*, p. 78.
[563] Literally: "before horse."
[564] Literally: "after horse."
[565] *Tasshi* 達 (*Government Notice*) concerning the reform, Cited in Okada Yoshirō, *Meiji kaireki*, p. 119.
[566] Tsukamoto Aketake Proposal, cited in Okada Yoshirō, *Meiji kaireki*, p. 127.

> and 10, and the long hand points to the place of 2, it means that the time is 9 o'clock and 10 minutes. Now, when the short hand passes the middle point and gets closer to 10, and the long hand progresses to the point of 8, this means that the time is 20 minutes to 10. It means that it would take another 20 minutes for the long hand to come back to its origin at 12. In this way, you can know the 60 minutes from the clock face and know what is the hour and what is the minute. …[567]

So what was the motivation behind the reform of the hours? Why change a system that worked perfectly fine and didn't have any apparent flaws? One possible explanation was the necessity of communication with the outside world. When looking at proposals submitted to the parliament or published in newspapers, we notice that the suggestion to reform the calendar was often paired with encouragement to learn geography or "the art of navigation."[568] As we have previously seen, Western pocket watches were closely associated with the kind of time used in navigation — the Greenwich mean time necessary for the calculation of the longitude. Some of the figures involved in the study of navigation indeed came to be quite influential in the new Meiji government, and it is possible that, similarly to the reform in calendar, they imposed their ideas on the general public. But this fact alone cannot explain why they didn't think it is necessary to justify their decision. There must have been a reason why people were already convinced.

A hint to this we can find in the words of Ichikawa Saigū, who claimed that "a recently imported pocket watch is very convenient not only because it is portable, it is also very detailed and benefits social interaction with people. Recently everybody carry it around and use its

[567] *Kairekiben* 改暦弁(Speech on Calendar Reform), in Collected Works of Fukuzawa Yukichi, pp. 329-330.
[568] In 1872 Takahashi Tamagusuku 高橋玉城 from Nishioji domain wrote both "On the Necessity of Reforming the Calendar" (*Kaireki subeki koto* 改暦スベキ事) and "On the Necessity of Learning the Art of Navigation" (*Kōkai no justu wo manabashimu koto* 航海ノ術ヲ学バシムベキ事). Then in 1873 Hirokawa Seiken wrote "On the Reform of the Calendar" (*Rekihō kaikaku no koto* 暦法改革之事) paired with "On the Urgency of Geography" (*Chiri kyūmutaru koto* 地理急務タル事), See Okada Yoshirō, *Meiji kaireki*, p. 78.

divisions of an hour. It is a very trusty and useful device,"[569] This point of view was shared by other reformers as well, since even the imperial restrict ordered everyone to start using "the hours of the *jishingi*." The official reform was just a formal step that recognized something that people were already using.

Making Sense of Western Time

But we might suspect that the process of adapting the western temporal system was much more complex. The system of twelve variable hours, counted as animal signs or a double nine-to four series is drastically different form the Western system of twenty-four equal hours. Simple exposure to Western watches cannot explain the readiness to adopt foreign system, which didn't match the social rhythms and cultural assumption of Edo Japan. Factually, as we have previously seen, Japanese consumers rejected the Western temporal conventions upon their initial encounter with Western mechanical timekeeping technology, so why would they readily adopt this same convention two hundred years after? If the Western system seemed to them nonsensical in the seventeenth century, how come it suddenly not only made sense but was perceived as desirable in the nineteenth century?

To these questions we should also add evidence suggesting that Japanese watch users, *did not* easily accept or even understand the Western convention. In his later memoir, Fukuzawa Yukichi,[570] recounted the following episode he was witness to in the final decade of Tokugawa regime:

> In the last years of the Tokugawa regime, the Western fashion gradually permeated through the society, and all the high officials in the government began carrying imported gold watches in the folds of their dress. Those gentlemen must have paid two hundred *ryō* or even three hundred *ryō* for each of those

[569] Ichikawa Saigū, in Okada Yoshirō, *Meiji kaireki*, p. 74.
[570]福沢諭吉 (1834-1901).

> watches, but very few of them know how to read the time. A group of these august men would be talking together in the palace waiting room and one of them would ask, "What time would it be now? What does your honor's watch indicate?"
>
> The gentlemen next to him would take out a shining gold watch and would say, "It is already past one o'clock."
>
> The first Gentleman would say: "Is it, Sir?" looking at his own watch, "Where does the long hand of your watch point to, Sir?"
>
> "The long hand of my watch is about three o'clock, " the other gentleman answers. This conversation indicates that the time was about quarter past one.
>
> Such were the conversations between those ponderous personages who did not know the real use of the watches.[571]

Fukuzawa's strong rhetoric suggests the ignorance of unenlightened feudal lords of the pre-Meiji era, who couldn't understand how to use such a simple instrument as watch. But if we distance ourselves from the ideological subtext weaved into the memoirs of Japan's most prominent modernizer, we observe, in fact, that this passage is a revealing testimony to the fact that reading Western watches was far from being obvious. To us, modern day readers, reading a clock seems almost intuitive; we think of a clock dial as self-explanatory and rather simple. Yet for somebody who has not had the experience of using a Western clock, the information contained on the clock face could be overwhelming, and there was very little obvious about the ways to read its time.

As Martha Chaiklin suggested in her book,[572] the import of Western clocks and watches was thriving throughout the Edo period. The overwhelming majority of these watches, however, were modified to fit the Japanese temporal convention. An early nineteenth century scholar, Satō

[571] Fukuzawa Yukichi, "Preface to the collected works of Fukuzawa," in *The autobiography of Fukuzawa Yukichi*, Eiichi Kiooka, trans. (Tokyo: Hokusaido Press, 1981), pp.76-77.
[572] Chaiklin, Martha. *Cultural Commerce and Dutch Commercial Culture: the Influence of European Material Culture on Japan, 1700-1850* (Leiden: CNWS, 2003).

Issai,[573] who owned a collection of various clocks, described one example of a modified foreign device that came into his possession: "Its shape is round, and it is covered with nickel; the dial is made of copper with golden engraving. In diameter it is a little more than one *sun*[574] and two *bu*[575] and it is less than seven *bu* thick. The round dial is marked with the twelve animal signs.[576] *Rat* and *Horse* are stable but the rest are movable, so that you can determine the length of night and day hours…This shape is a consequence of modification that was made in Japan. Previously it was enameled, and on the outer edge there were sixty minutes and on the inner edge there were twenty-four "small hours", all of them written in Western letters in black enamel."[577]

The task of modification was not easy. For example, the small size of pocket watches did not leave enough space for digits to be moved closer to represent shorter hours; but making the digits themselves smaller would make the markings illegible. Also, the teeth of the altered gears did not always correctly correspond to Japanese hours, and the index hand could point to a wrong place. It was the clockmaker's task, to "change [the watches] into Japanese style, and make a new display, in order to allow people to know the hours and their exact divisions."[578] Clockmakers thus were the first to learn the Western style of time reckoning system, because they had to understand the relation between the workings of the inner mechanism and the appearance on the dial.

[573] 佐藤一斎 (1772-1859).
[574] 1 inch.
[575] 0.1 of an inch.
[576] 時辰.
[577] Satō Issai, *Yōsei sokujiki* 洋製測時器 (*On Western-made time measurement devices*), 天保九 (1838), Tohoku University Kano Archive. Also published in Okada Takehiko 岡田武彦, ed., *Satō Issai Zenshū* 佐藤一斎全集 (Complete collection of Satō Issai's works), vol 2, (Tokyo: Meitoku Shuppansha, 1991), pp. 160-165.
[578] Fujimura Heizō 藤村平三, *Jimeisho jiban kō* 自鳴鐘時盤考 (*Investigation of the clock dial*), 文政六 (1823), Published by clockmaker Tōda Tozaburō 戸田東三郎. National Diet Library.

In spite of this practical solution of a Western mechanism combined with a Japanese dial, in the final decades of the Tokugawa period it became fashionable to carry Western pocket watches, without modifying the dial. One possible reason for this change was practical – the clockmakers could not keep up with the demand for the clocks and the large quantities of imported devices. Nevertheless, it seems that the main reason behind this tendency was a change in how watches were perceived — no longer just as timepieces, but as an indication of the sophistication of its owner.

First, we must take into an account the previously described change in the perception of the machine itself. As we have seen in chapter three, by the beginning of the nineteenth century, mechanical devices came to be seen as a representation of the natural world. Understanding the workings of any mechanical device meant understanding the laws that governed the universe. As participants in this large category of mechanical devices, clocks and watches were no longer seen just as time-measuring devices. In fact they were appreciated *mostly* as mechanical devices, as boxes with moving gears. If the ability to tell time off of the watch came to be seen as secondary, it is not surprising therefore that Japanese users were buying an interesting device, even if they were not sure how to use it.

But these watches were not only mechanical devices, they were also *Western* mechanical devices. Another attribute that made Western watches intriguing was the mere appearance of numbers on the dial. With the growing acknowledgement of the importance of commerce and the subsequent rise in the status of mathematics, numbers came to be seen as rational and objective, and were taken to be a direct expression of economic aptitude. Scholarly discussion of economic as well as of moral affairs came to include more and more numbers that served as a testimony to the objective description of the state of affairs. Foreign numbers were especially regarded as a

symbol of efficiency due to a kind of utopian vision of the West as efficient, calculated, productive and lacking wastefulness.[579] A material manifestation of numerical fashion is seen in the Japanese clocks themselves – in these years additional visible dials with Arabic numerals 1, 2, 3, or even 1, 2, 9 began to appear on *shaku* clocks. These dials had absolutely no function besides showing their owners the rapid movement of one quick hand, assuring them that the clock indeed worked. The tiny hand measured neither minutes nor seconds, and the numbers did not have any significance besides being Western, yet their presence on the dial elevated the value of the clock.



Image 17. *Shaku* Clock. Seiko Horological Institute. (author's photograph)

The photographed part of the clock is not a dial but rather a box containing most of the mechanism. The glass window, as mentioned in *Illustrations of Curious Devices*, is there to enable one to peek into the mechanism and look at the elegantly exposed gears. In this particular clock we also see the upper dial with an additional index hand that does not indicate any time units correlating to Japanese time, but rather ambiguous and equally distributed Arabic numerals 1,2,3.

[579] For discussion of the image of Western numbers, see Annick Horiuchi, "Honda Toshiaki (1743-1820) ou l'Occident comme utopie" in F. Girard, A. Horiuchi, M. Macé (dir. & éd.), *Repenser l'ordre, repenser l'héritage: Paysage intellectuel du Japon (XVIIe -XIXe siècles)*, Droz, 2002, p. 411-448; A specific reference linking number counting and Western watches can be seen in Tadano Makuzu's "*Hitori Kangae*" - see Goodwin, Gramlich-Oka, Leicester, Terazawa, and Walthall, trans., "Solitary Thoughs – a translation of Tadano Makuzu's *Hitori Kangae* (2)," in *Monnumenta Nipponica* 56, 2, (Summer 2001), p. 193.

Yet it was not only the numbers on the dial of the clock that created the association with efficiency, sciences, and societal advancement. Western watches were perceived to be the same category of devices as marine chronometers, which, as we could see in the previous chapter, not only became one of the primary tools of astronomy but also that of the newly emerging and fashionable science of navigation. The inability to actually sail abroad did not prevent early nineteenth century Japanese from imagining sea voyages that would lead them to social advancement and economic prosperity, as Honda Toshiaki famously propagated in his *Treatise on International Commerce*.[580] A chronometer, therefore, came to be seen as a tool of advancement, as a device that provided one with an objective time necessary to the meticulous astronomical and nautical calculations.

This idea that pocket watches and marine chronometers were tools of advancement could also be seen in the name they both were referred to — *jishingi*.[581] It was, of course, clear to everybody that this was still a kind of clock, *tokei*,[582] even though it was miniature and often referred to as *netsuke clock* or a *sleeve clock*[583] (i.e., a "pocket clock" since long sleeves were used as pockets), yet the new name reflected something more than the miniature size of the device. The first two characters both signify an "hour," while the last one is simply a "device," so that one still has an "hour device" or, "time machine", if you like. Nevertheless, the addition of this last character is in fact crucial, because the character "device" was usually added to

[580] Honda Toshiaki, *Kōekiron* 交易論, in *Nihon Shiso Taikei*, vol 44, pp. 175-183.
[581] 時辰儀. It is very difficult to distinguish between chronometers and pocket watches at the time. Not only that they were referred to by the same word in Japanese, but in the Western languages too, pocket watches were often referred to as "chronometers." It is only when we see a description of one of these devices that we understand whether it was a pocket watch (e.g. small, round, portable device) or a marine chronometer (e.g., a clock enclosed in a box and stabilized to decrease the influence of any outside disturbance).
[582] 時計.
[583] 根付時計, 袖時計.

astronomical instruments and bore a somewhat honorific sound. *Jishingi*, therefore, was more than any existing clock, it was a tool of sophistication, efficiency and investigative mind.

This does not mean, however, that everybody knew immediately how to use this device. The mere possession of it was already enough to cast the light of sophistication on the owner. Seeing this, many scholars criticized the new fashion, and complained that most people took these recently imported miniature watches, and "just played with them for fun, looking at the structure of this new technology, as if it was not a device meant to show the daily time of heaven's movement…."[584] But this criticism shows perhaps more arrogance on the part of the scholars than the actual state of affairs, as even unprofessional users became interested in the meaning behind the odd appearing clock dials and attempted to learn how to read time off of them. However, as one of the authors, Fujimura Heizō, put it: "one invests all his strength into trying to get into the mind of the Westerners, but it is still not easy to figure out."[585]

It seems that the most straightforward way to learn the Western style of time reckoning would be to get the theoretical basics of the foreign system. Yet the learning process was far from simple – rather than just gathering pieces of information, in order to reach the point when one internalized the Western convention of reading time, one had to learn how to solve apparent conundrums, overcome one's own existing assumptions, and ignore irrelevant information. This was a complicated process that really involved "getting into the minds of Westerners" – learning not only simply practices but also an entire worldview.

It is true that all those who wrote about Western clocks seemed to start with the theoretical outline: in all Western countries there are twenty-four hours in one day and their

[584] Kyūshidō Shujin 求巳堂主人 (according to Watanabe Toshio, this was one of the pen names of Shibukawa Kagesuke 渋川景佑), *Shōchū jishingi jimō* 掌中時辰儀示蒙 (*Pointing out the Ignorance About Pocket Watches*), 文政六 (1823), Tokyo University Library.
[585] Fujimura Heizō, *Jimeisho jiban kō.*

length does not change with the seasons.[586] But this kind of theoretical outline did not make much sense to people who were used to a different kind of time. The immediate next step in the process of explanation was therefore to interpret these new units using familiar terms.

Although it was said that in the West there were twenty-four hours in one day, "these were not the same hours as Japanese ones, and only during the equinoxes were the hours comparable."[587] Since in Japan there were only twelve hours to a day, the Western hours were obviously seen as short, and several authors suggested calling them "small hours."[588] Conversely, one could think of those not as hours at all, taking them only to be "rotations" of the hour-hand, a manifestation of the inner working of the mechanism on a dial.[589] In order to get the feeling of these small, equal time units, Western hours were described in terms of equal time units familiar in Japan - the astronomical *koku*. But, many authors noted, in the West there are not one hundred but only ninety-six *koku* in one day, and each hour is exactly four *koku* long.[590]

The count of hours started at the ninth hour of noon – a place that is marked in a Western dial by the Roman numeral XII. "From this place to the next marked by I it is one small hour. To the place marked II it is two small hours, to the place marked III it is three small hours….."[591] Now, since "the dial of the clock is too small, you cannot divide it into twenty-four, because if you do so, the divisions between small hours will be too close, and inconvenient to see…Therefore, [the dial] is divided into twelve hours, and from the ninth hour of the noon to

[586] Shūyūdō Shujin 尚友堂主人 , *Waei tsūin iroha benran* 和英通韻以呂波便覧 (*English-Japanese basic guide*), alternative name *Iroha Benran*, 慶応四 (1868), National Diet Library.
[587] Shūyūdō Shujin, *Iroha benran*.
[588] 小時. Shūyūdō Shujin, *Iroha benran*, Fujimura Heizō, *Jimeisho jiban kō*.
[589] 回 Ogawa Tomotada , *Seiyō jishingi teikoku kassoku* 西洋時辰儀定刻活測 (On time measurement with Western watches), introduction dated 1838 , main text dated 1857, Kano Bunko Archive.
[590] Fujimura Heizō, *Jimeisho jiban kō*.
[591] Fujimura Heizō, *Jimeisho jiban kō*.

the ninth hour of midnight it makes one round, and then an additional round until the noon of the next day, making it twenty four small hours that are easy to see."[592]

But herein lies another problem – Western watches had not just one, but two and sometimes even three index hands. And those hands made revolutions all day long, confusing Japanese users. The solution was to choose the most important hand and to focus on just one, and the authors of the Western clock guides all agreed that for the purpose of knowing the hour the long hand is in fact more important than the short one.[593] If you look closely, suggests Fujimura Heizō, you will see that in a Western watch there is an inner and an outer dial. On the inner dial there are the Roman numerals signifying hours: I, II, III, IIII, V…, but on the outer dial there is a different style of numbers. Exactly above the XII digit, "in the palace of the ninth hour of the noon, there is 60. When the long hand reaches 15, it means that it made one *koku*, when it reaches 30 it is two *koku*, when it reaches 45 it is three *koku*, and when it comes back, it is 60 and four *koku*,"[594] namely one hour. At noon, both the long and the short hand came exactly to the same place.

This seemed to be a reasonable explanation, and yet, no matter how hard the authors of these treatises tried to make sense of the foreign system using their own, familiar terms, Western time and Western clocks still seemed to be bizarre and confusing. And it is precisely those aspects of the Western method that we, modern-day readers, perceive as obvious and functional that aroused the greatest puzzlement in mid-nineteenth century users of Western watches.

A major confusion was caused, of course, by the nature of Western hours that failed to reflect the seasonal changes in the length of the day. For us, the so-called "variable" hours of

[592] Fujimura Heizō *„Jimeisho jiban kō.*
[593] For example, Shūyūdō Shujin, *Iroha benran.*
[594] Fujimura Heizō, *Jimeisho jiban kō.*

Edo Japan seem to be "changing" and unstable; but for the Edo-period Japanese Western hours seemed to be unstable. After all, Western hours were sometimes longer and sometimes shorter than the Japanese ones. Besides, in Edo Japan both dawn and sunset always occurred in the sixth hour. In fact, they were defined by the fact that they always occur in the sixth hour: *akemutsu* (the six of the dawn)[595] and *kuremutsu* (the six of the dusk).[596] But in the West, writes astonished Yanagiwa Shunsan, "sometimes dawn is in the fifth hour, sometimes in the sixth, and the same with the sunset."[597] Moreover, the dawn and the sunset in the West did not correspond to any round hour at all, occurring in a certain number of "rotations" of the short hand plus several minutes indicated by the long hand. All these made it impossible to know the time of the dawn or the dusk by looking at the clock – one had to know beforehand the exact number of rotations both of the short and the long hand that indicated dawn in each season in order to know whether the dawn is about to come or had already passed. Therefore, complained Satō Issai, these Western watches were very difficult to measure the variable hours with.[598]

[595] 明け六つ.
[596] 暮れ六つ.
[597] Yanagiwa Shunsan 柳河春三, *Seiyō tokei benran* 西洋時計便覧 (Basic Guide for Western Clocks), in *Meiji bunka kenkyukai* 明治文化研究会 (Research Society of Meiji Culture) ed., *Meiji Bunka Zenshu* 明治文化全集 (*Collected Materials of Meiji Culture*) vol. 20 (Tokyo: Nihon Hyōronsha, 1992), p. 16.
[598] Satō Issai, *Gaishi jiki zakki* 磑子時器雑記 (Records of a Ticking Timepiece), 文政一 (1818), Kano Bunko Collection.

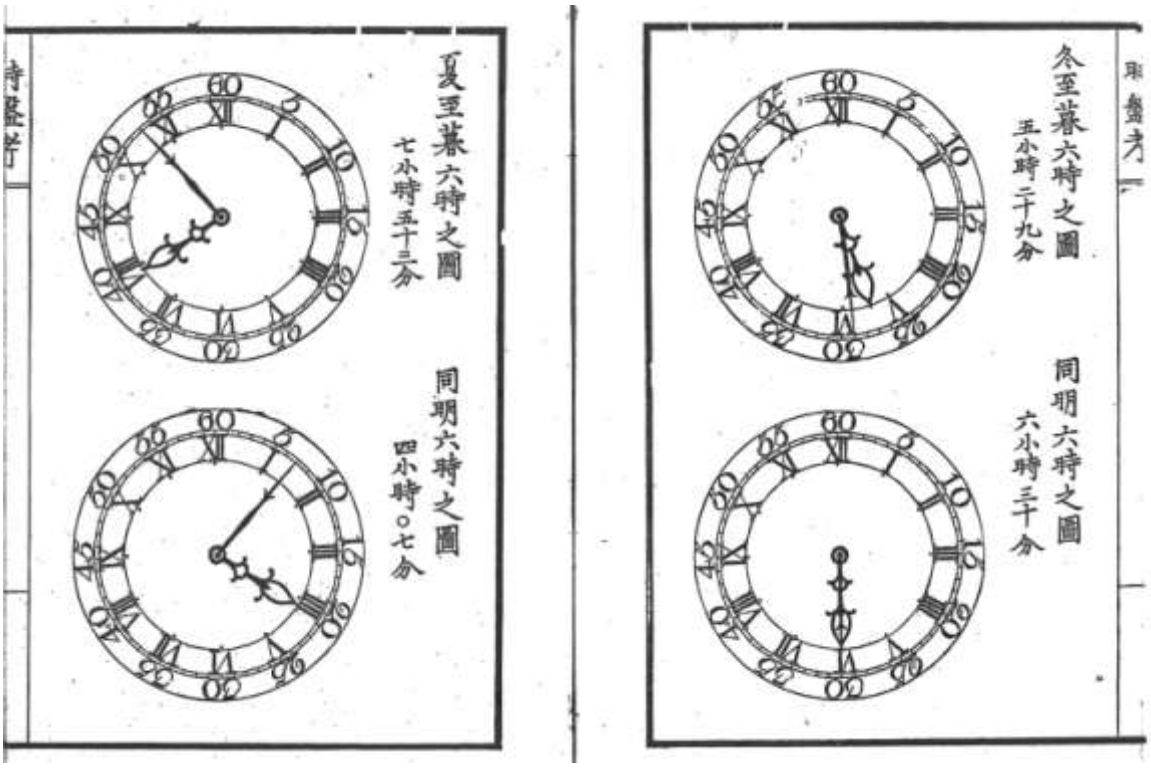

Image 18. *Jimeisho jiban kō* (*Investigation of the Clock Dial*) National Diet Library.

Illustration of "unstable" Western hours. From upper right, clockwise, the pictures indicate the position of Western index hands on 1) the sixth hour of sunset during the winter solstice, 2) the sixth hour of dawn during the same season 3) the sixth hour of dawn during the summer solstice and 4) the sixth hour of sunset during the summer solstice. Note the impossible position of index hands on the bottom right – it seems that the author thought that the position of the hands at the bottom has to parallel that at the top.

This inconvenient feature of Western watches was not the only thing that bothered this erudite scholar and clock collector. Well versed in the sciences, and particularly in astronomy, Satō Issai could not comprehend how Western units could correspond to astronomical calculations. First of all, factually, "the numbers on this watch did not match the calculations made by astronomers, and it was hard to use."[599] But moreover, it was not only the fault of one specific watch, the whole system seemed unreasonable. Prior to the introduction of marine

[599] Satō Issai, *Gaishi jiki zakki* 磕子時器雑記 (*Records of a ticking timepiece*).

chronometers in late 1820s, astronomical calculations were made using the number of pendulum oscillations, which also was a recent invention that replaced the astronomical decimal system of hundred daily *koku*. But the "ninety-six Western *koku*" seemed to be unreasonable for any mathematical calculation, and did not correspond even to the Western dial itself with its sixty-minute divisions.[600]

But even for the seemingly unproblematic everyday use these clocks posed several major challenges. How does one look at the watch? Where does the day start? What is the correlation between the hour, the minute and the second hand? The answers to these questions were not that obvious even to the most erudite writers. Thus, for example, Shūyūdō Shujin perfectly described the correlation between the Western and the Japanese hours, and yet he insisted on depicting the watch in a manner that from a modern day point of view seems "upside down," with the number XII depicted at the bottom. Trying to explain the same exact correlation, the anonymous author of the *Outline of Western Watches* wrote that "exactly at midnight, both hands point to the earth, overlapping," but then he (or somebody else) crossed out this explanation and wrote: "exactly at midnight the minute hand points to the skies, while the hour hand points to the earth." [601] Wrong again! Why was it so hard to understand? The reason was perhaps that the Western way of looking at the clock was absolutely opposite to the Japanese convention, where the midnight hour is depicted in the bottom of the dial, and it seemed unreasonable that the position of the hands at noon and at midnight would be exactly the same.

But even if one understood how to read a Western watch, and learned to accept its oddities, there still was one major problem: Western watches simply gave one a wrong kind of time. They might have had three index hands and could measure minutes and seconds, but unless

[600] Satō Issai, *Gaishi jiki zakki* (Records of a ticking timepiece).
[601] Anonymous, *Jishingi Teiyō* 時辰儀提要 (*An outline of Western Watches*), Gakushiin Archive.

one knew what Japanese hours those corresponded to, these watches were completely useless for knowing the Japanese, seasonal time.

One solution to this problem was to create "translation" tables that would interpret Western time and render it into a meaningful form. And indeed, many of the clock manuals, such as the treatise *On the Movement of the Three Hands*,[602] or *An Outline of Western Watches*,[603] simply provided "translation" tools.[604] These could be written tables, comparative pictures or even paper models.

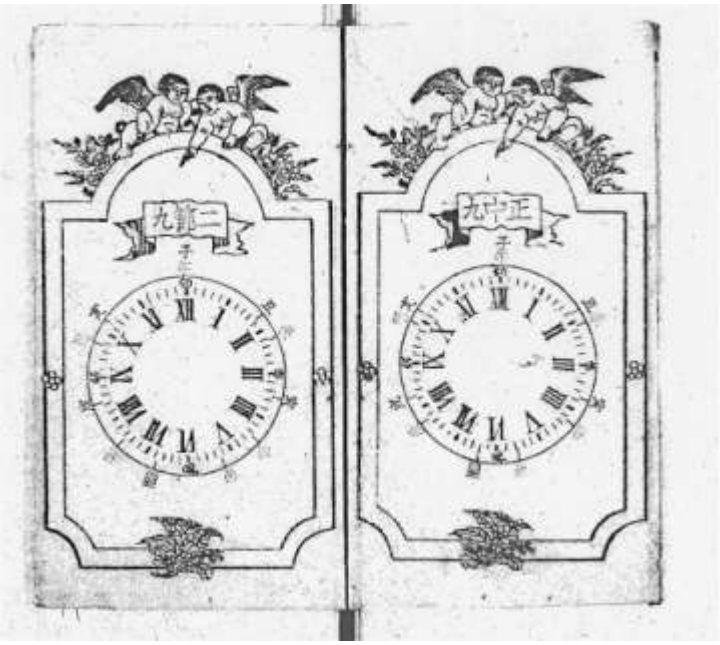

Image 19. *Wayō Taishō Tokei Hyō* (*A Comparison Table of Japanese and Western Clocks*). National Diet Library.
Pictorial comparison of the position of the hours – on the outer edge of the dial Japanese characters indicate the position of Japanese hours – night hours in black and day hours in red (brighter color in the illustration).

In order to explain how one should read and understand the table, Ogawa Tomotada provided a lengthy description of the principles lying behind the compilation of the table. He wrote down columns of hours in different seasons, where each entry was supposed to be divided into right and left parts, for "rotations" (i.e., Western hours) and minutes appropriately; the day

[602] Kawaguchi Jusai 川口戎斎, *Sanshin Hatsuei* 三針発映 (*On the movement of the three hands*), 慶応二 (1867), Kano Bunko Archive.
[603] Anonymous, *Jishingi Teiyō* 時辰儀提要 (An outline of Western Watches), Gakushiin Archive.
[604] See also Yanagiwa Shunsan *Seiyō tokei benran*, in *Meiji Bunka Zenshū*, vol. 20, pp. 17-19; and Anonymous, *Wayō Taishō Tokei Hyō* 和洋対照時計標 (*A Comparison Table of Japanese and Western Clocks*), Bakumatsu Period, National Diet Library.

entries were to be written in red and night ones in black. Then, knowing the Japanese hours, he wrote down the number of rotations and minutes. For example, he said "in mid September, at the eighth hour of the day, looking at the entry that matches the eighth hour, I wrote down on the right in red 'two rotations,' on the left side wrote nine *bu*. Therefore, when it is two rotations, and nine *bu*, you know it is the eighth hour. And at the sunset hour, in the entry of 'six', I wrote in black on the right side 'six rotations,' on the left 'seventeen'. Therefore when it is six rotations and seventeen *bu*, you know it is the sixth hour of the sunset. All the others are the same."[605]

But it seems that every solution, no matter how good it was, produced more and more problems. What if you are caught without your tables? What if you accidentally left them somewhere?[606] Does it mean that you cannot use your watch anymore? Not necessarily, replied Ogawa Tomotada – there is a way to know the hours without looking them up in the manual. The first step, he advised, was to remember the correspondence "as if there was no seasonal differences" and take it "as a basis for further calculations": twelve rotations is the ninth hour, one rotation is ninth hour and a half, two rotations is the eighth hour etc. etc. Then, one should remember by how many minutes Western hours grow or shrink relative to the Japanese hours, and add or subtract minutes accordingly. Thus, for example "during the first month,[607] the half-Japanese hour of the day is one rotation and two minutes, and half-hour of the night is one rotation minus two minutes; therefore one should add two minutes to every one of day hours and subtract two minutes from night hours. Therefore, a nine-and-a-half hour of day would be: "equal half an hour", plus one rotation (of the short hand) multiply by two (minutes of the long hand), and so you get 1 and 2 minutes; from nine-and-a-half to eight: "equal half an hour," then

[605] Ogawa Tomotada, *Seiyō jishingi teikoku kassoku* (On time measurement with Western watches).
[606] Ogawa Tomotada, *Seiyō jishingi teikoku kassoku* (On time measurement with Western watches).
[607] Around second half of February according to the current calendar.

two rotations multiply by two minutes and you get 2 and 4 minutes,….."[608] Ogawa dismissed concerns that this system was overly complicated. All you need to do, he explained, was remember how to determine the changes from season to season, which was done by translating the difference in the degree of earth's movement relative to the sun into time units of hours and minutes.[609] With all these calculations, it really seemed that one would be better off to remember to carry around the translating table, and be careful not to forget it anywhere.

Ogawa's calculations are nevertheless quite suspicious, to say the least. In his tables, hours always "grow" or "shrink" by exactly two minutes each hour, and although he mentions the fact that seasons are not symmetrical, the seasonal change is always described in three-minute units. Moreover, in Ogawa's tables, during the equinoxes, the sixth hour of the dawn and the sixth hour of the sunset fell exactly on round Western hours, perfectly reflecting the theory but nevertheless failing to note what was happening in reality. It seems that rather than being based on actual astronomical calculations, Ogawa's table provided a convenient approximation that could serve as a mnemonic device for remembering the equation, and later gradually developing an eye for intuitive "translation" of the utterly different number one saw on the Western dial.

[608] *Ogawa Tomotada, Seiyō jishingi teikoku kassoku* (On time measurement with Western watches).
[609] *Ogawa Tomotada, Seiyō jishingi teikoku kassoku* (On time measurement with Western watches).

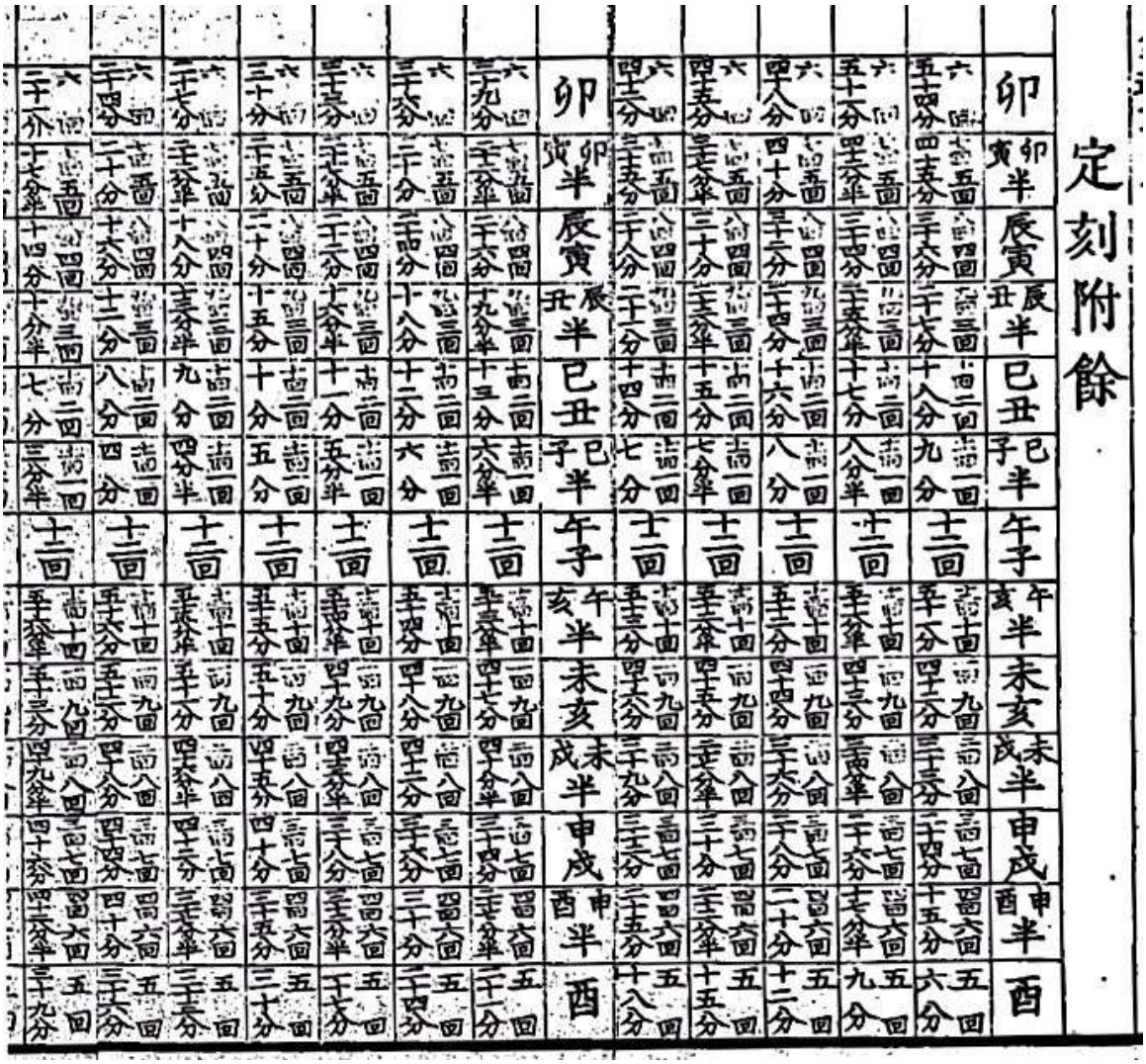

Image 20. Time-translation table. *Seiyō jishingi teikoku kassoku* (On time measurement with Western watches). Tohoku University Kano Archive.

Looking carefully, we notice the suspiciously neet and constant units by which hours changed their length throughout the seasons.

The choice of a table as a medium for translation was not accidental, as tables of all sorts were widely used in the Edo period astronomical writings, but also in practices that went beyond professional circles. As mentioned earlier, the yearly distribution of the length of hours was often represented as a table. Paper sundials were built as miniature tables and graph-like *Shaku* clocks

that imitated their shape also showed time in a kind of table. Moreover, tables were used by bell-keeper who needed to know how to translate astronomical calculations done in equal *koku* into the everyday system of variable hours, which they were supposed to notify the public about. In fact looking at the bell keepers tables from the Kaga domain, it is impossible to ignore the similarity between those and Ogawa's. Both the visual structure of the table and the gradual change of hours' length are virtually the same, suggesting that the choice of a table was not a novel invention but rather a conscious choice of a familiar medium. The content of Ogawa's tables, and the purpose to which they were intended were new; yet Ogawa only filled this content into already existing format — a conventional practice of using tables as translation tools that fostered the ability to quickly spot the relevant columns and visually identify the cross-sections of various types of information.

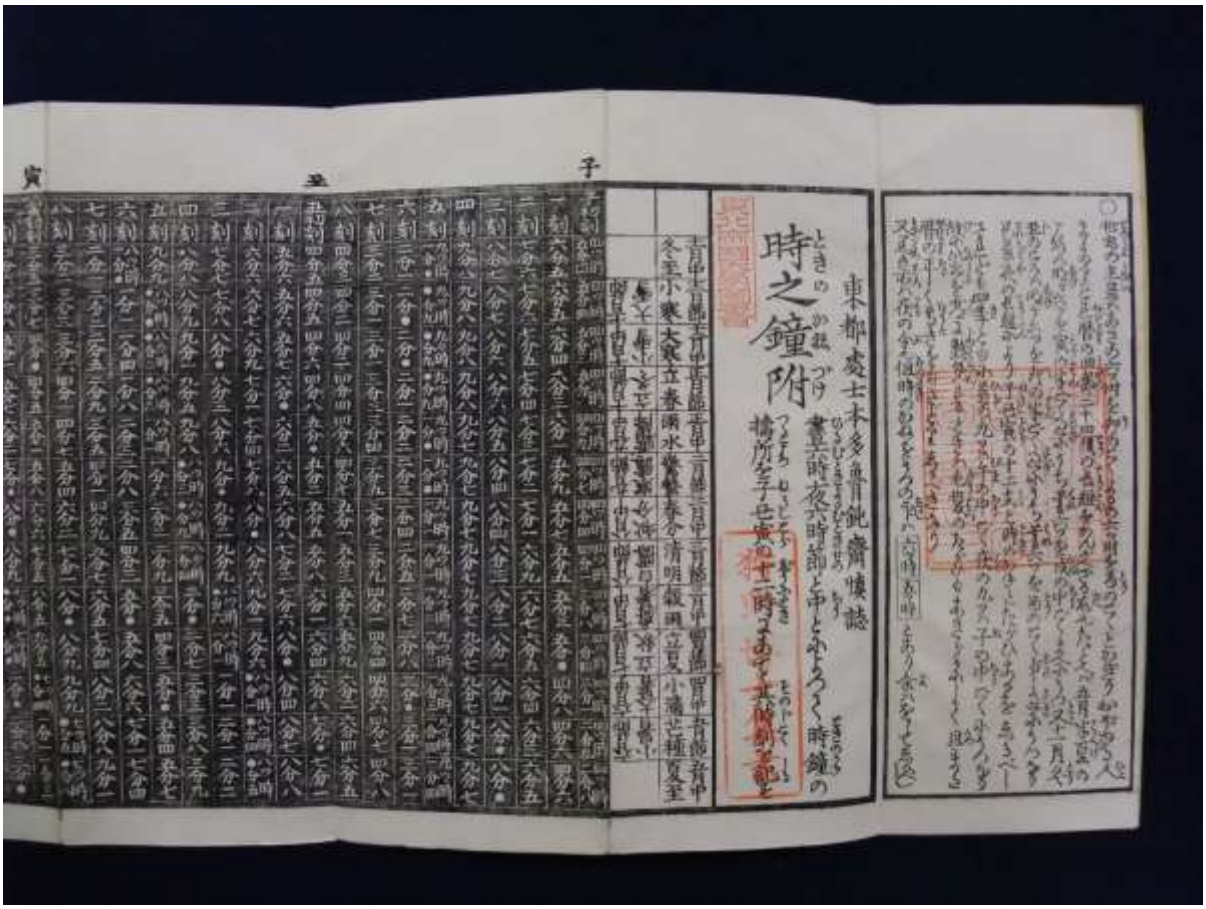

Image 21. Partial image of *Time-Bell Instructions*. Tohoku University, Kano Archive.

The x-axis indicates hours inscribed above the table. The y-axis indicates the different seasons. The table based on units of equal length used for astronomical calculations. In this system a day was divided into twelve equal hours indicated by the twelve animal signs as well as into a hundred equal *koku*, so that each hour had 8 1/3 *koku*. Each *koku* was further divided into ten *bu*, which again was divided into ten sub-division, not indicated here by a specific term. Consequently, the exact length of variable hours, which are indicated by their numbers, is written inside the table in terms of hours (*jishin*), *koku*, and *bu*.



Image 22. Partial image of *Time-Bell Instructions*. Tohoku University, Kano Archive.
During the season of winter solstice (the upper row below the x-axis) the sixth hour of dawn will start at 7 *koku* and 0.9 *bu* after the equal hour of the Rabbit. In the next mini-season, however, it starts at 7 *koku* and 0.7 *bu*; next — at 6 *koku* 0.2 *bu* etc.

But let us return to the problematics of Western watches. All the recognition and translation guidelines only work if the clock functioned perfectly. The next, crucial stage in learning a new system was to recognize when things went wrong, and to distinguish between what was meaningful and what was meaningless. One important task was to make sure that the clock was calibrated properly, which was done by verifying that both hands of the clocks were absolutely aligned exactly in the middle of the Roman numeral XII. "If this is correct, then the hands of the clocks will make rounds and rounds throughout the day and return to the same position exactly at noon. But if you fail to ensure this position exactly at noon," warns Ogawa Tomotada "no matter how detailed the division of the hour, the watch wouldn't be worth much."

And how would you know when noon was? By using a sundial, of course. The practice of calibrating mechanical clocks according to sundials was relatively widespread throughout the Edo period, so that it was only obvious that Western watches too should have been calibrated according to the sundials, which showed the "true," namely seasonal time.[610]

Calibration of the watch was not the only problem. Although early nineteenth century European watches are now considered to be relatively precise, there were in fact often problems with the mechanism, and as Ogawa Tomotada mentions "it often happens that the gears are not properly adjusted, and even though the long hand already made one round, the short one is still two-three *rin*[611] from twelve. But, if the long hand had reached the center of the numeral XII, it counts as one rotation. Sometimes it also happens that the long hand points only to 55 minutes and there are still four-five minutes to the completion of the rotation, but the small hand is already at the center of the next numeral. But, until the long hand reaches the exact center of the numeral XII, it does not count as one rotation. Therefore, the measurement by the short hand is only approximate," and consequently, one should focus one's attention on the long hand and ignore the short one.

Indeed, in order to get to *know* this new system also required learning how to *ignore* certain features by rendering them unimportant. Thus, for example, describing his first encounter with a Western watch, Satō Issai meticulously noted the correlation between the movements of the different hands. "In one *koku*, the hour hand moved 1 *bu*, 5 *rin*, 5 *gō*[612]…. when a "second" hand moves 45 *bu* the minute hand moves 7 *rin* 5 *gō*." [613] The author of *An Outline of Western Watches* listed all the times when the two hands overlap: at one o'clock five minutes and five-

[610] Ogawa Tomotada, *Seiyō jishingi teikoku kassoku* (On time measurement with Western watches).
[611] 厘 one hundredth of an inch
[612] 毫 one tenth of *rin.*
[613] Satō Issai, *Gaishi jiki zakki* 磕子時器雑記 (*Records of a ticking timepiece*).

elevenths of a minute, at two o'clock ten minutes and ten-elevenths of a minute, etc. These calculations were obviously a result of a serious investigation – yet they were absolutely unnecessary, at least for actually using the clock. The same author later turned the explanation of the clock into a series of mathematical riddles of increasing difficulty, such as: "you have three clocks – one is speeding by three minutes and twenty seconds in twenty four hours, another is slow by three minutes and yet another one [is regular]. What would be the next hour that all three of them would show the same time?"[614] These riddles seem to be an interesting exercise in algebra, and those who managed to solve them certainly gained more knowledge about the Western dials. Yet this knowledge was absolutely superfluous for using the watches in order to read time. Indeed, the more accustomed late Tokugawa users got to Western watches, the more focused and narrow their gaze became. To be more precise, the authors who wrote in the end of the Tokugawa period urged that one only focus his attention on the hand that measures the units he wants to know, and ignore the correlation between all different hands.

So, those Tokugawa officials that Fukuzawa Yukichi mocked were completely correct to focus on the long hand. In fact, they were doing exactly what the *Useful Guide to Western Clocks* instructed them to do: "When looking at the hour, it is better to look at the long hand, since the short hand is making only two rounds, the divisions are little and hard to distinguish. The long hand makes one round in one hour, so that it makes twenty-four rounds in a day. So when you look at the long hand, you know what hour and what minute…. Both hands should be in the same place when they are at 12, if not, it means that there is something wrong with the clock." [615] And by following the manual in this way, they learned how to make sense of the

[614] Anonymous, *Jishingi Teiyō* (*An outline of Western Watches*).
[615] Yanagawa Shunsan, *Seiyō tokei benran*, in *Meiji Buka Zenshū*, vol 20, p. 16.

plethora of information coming from the clock dial, and how to focus on the meaningful and significant information while ignoring the accidental and meaningless aspects.

And there were some people who succeeded in this task pretty well. In fact, they understood the logic behind the Western temporal system so well that they wanted to extend it even further and experiment with the system. Fujimura Heizō did precisely that. After learning the system, he no longer thought that the Western system was inconvenient or cumbersome, but rather straightforward and potentially useful. Focusing on the hour announcement by bells, he described the Japanese system in the following manner: "in our clocks, when you want to announce half past six, four or eight, you strike twice; when you want to announce half past five, nine or seven, you strike once."[616] So that if one were to listen to the sequence of bell announcements from the noon hour, one would hear: 9 strikes, 1, 8, 2, 7, 1, 6, 2, 5, 1, 4, 2. "If you are not familiar with this system," claimed Fujimura, "you would be confused about the hour. But in Western clocks, it is one strike for one o'clock, two for two o'clock, etc., the bell just strikes the number of hours, and therefore there is nothing ambiguous here." However, he notes, "when the number of strikes is too large, when you listen to it you are prone to make a mistake," and therefore the clocks do not strike twenty-four times, but rather repeat the much more sensible sequence of one to twelve. But taking this logic of the Western system even further, he claimed that twelve strikes too, are way too much for one to listen to. He therefore suggested striking the bell in the following way: "As it is described in the picture, the ninth hour is on the numeral XII. From this place – after two *koku* you make one voiced strike [617] and when it reaches I you make one voiceless strike.[618] In this fashion, you mark every two *koku*. From

[616] Fujimura Heizō, *Jimeisho jiban kō* (*Investigation of the clock dial*).
[617] *Dakushō* 濁鐘.
[618] *Onshō* 音鐘.

sixth hour you sound again one, two, three, etc., but [in your head] add six, and then it would mean the seventh, the eighth hour, etc."[619]



Image 23. *Jimeisho jiban kō*. National Diet Library.
The alternative time-bell system of Fujimura Heizō. One dull strike between XII and I, then one voiced sound on I; two dull sounds half past I, and then two voiced sounds on at II etc. Half past six one returns to one dull strike and continues in the similar manner. The cycle repeats itself four times a day.

This reform in the time-bell announcement system was not the only reform Fujimura had suggested. He also designed a new system that would combine the advantages of the Western two-handed dial with the Japanese system: "As it is described in the picture, we can divide the circle into 100 *bu*, which would also correspond to 100 *koku*. Then, it is very easy to know the position of the digits (*warigoma*) in every season.[620] It is such a simple design but right now it is neglected and people just follow the long hand. But with this design, the short hand will make

[619] Fujimura Heizō, *Jimeisho jiban kō* (*Investigation of the clock dial*).
[620] Since the differences in the length of hours are defined according to the astronomical 100-*koku* division of a day.

one round in one day and the long hand will make one round in every half an hour, so that every *koku* will be 25 *bu* long."[621]

This system actually makes a lot of sense in the late Tokugawa context, and if the reformers of that period aimed only for the efficiency, as they claimed, they could find it in this model. But actual practice was not the question, because they didn't want just efficiency, they wanted a *Western efficiency*. Consequently, people aimed to accept the Western temporal convention. In the early Meiji period, Western watches came to be associated with the new values of precision and modernity. Writing in 1877, Kumagai Tōshū stated: "a clock is a machine that is associated with modernity. It helps people to know exactly whether the time is late or early and not to be embarrassed by being late to appointment. It benefits the whole nation (*kokka*) … this [progress] only happened four, five years ago."[622]

The conceptual shift from the unequal Japanese hours and the clock dial that corresponded to them to the Western style time-telling system was far from smooth. Even after the seasonal time was abandoned in favor of a Western timekeeping system in a sweeping reform at the beginning of the Meiji era (1873), people still struggled to accept the weird system in which sunset and sunrise kept changing their positions.

But the Western convention became more and more accepted, forcing even the most stubborn adherents of variable hours to change their practices. These changes were clearly reflected in the timekeepers used in the Meiji period– in some cases the clocks were designed to show both systems, or at least give to the confused user a hint as to what Japanese hour, more or less, the Western clock pointed to. In other cases, existing Japanese clocks underwent cosmetic

[621] Fujimura Heizō, *Jimeisho jiban kō* (*Investigation of the clock dial*).
[622] Kumagai Tōshū 熊谷東洲, *Jishingi no setsu* 時辰儀の説 (*Explanation of a clock*) Tohoku University Library Online Wasan Collection (http://dbr.library.tohoku.ac.jp/infolib/user_contents/wasan/l/t009/14/t009140003l.png last accessed April 2012).

surgery, and their dials were replaced by Western style digits positioned in a Western style of time keeping. Even though those devices still could have measured time in variable hours, the equal hours gradually became permanently fixed on the dials, as well as in the minds of the people.

Conclusion

So how does time become convenient or inconvenient? In the case of the temporal revolution of the mid nineteenth century there were several factors that shaped the perception of what was inconvenient and inefficient and what was logical, useful and progressive. One thing that we can say for sure, however, is that none of those factors was related to the actual astronomical observations and or mathematical calculations that stood at the basis of creating human time — the calendar and the division of the day. Unlike the numerous previous calendrical reforms, the temporal revolution of mid-nineteenth century did not attempt to *correct* or *improve* the system, so that it would better reflect the established criteria. Rather, it undermined the validity of the whole system altogether.

Wrapped in the rhetoric of (in)convenience and (in)efficiency, the motivations behind calendrical reform had little to do with the actual practice. The reformers were rather concerned with the state of "the people," whom they saw as superstitious and unenlightened. Fed by the utopian image of the West as a pinnacle of efficiency, they found fault with any aspect of the existing calendar that differed from the Western one, sometimes without even a real understanding of the Western temporal system they adored. Sure enough, they legitimized their claims by referring to what they perceived were agricultural practices, yet it seems that their arguments were rarely based on the experience of people who actually dealt with agriculture. In

fact, "the people" had to be convinced that what they were used to was in fact, inconvenient and inefficient.

Curiously enough, none of this rhetoric is seen in relation to the division of hours in a day. Even more curious is the fact that whereas in the case of the calendar there was a clear line stretching directly from the earlier utopian ideas of reform to the imperial rescript of 1873 reform, in the case of the daily time there was a contrast between the earlier thinkers and the actual reformers. Whereas earlier thinkers didn't even aim to reform the hours, the later ones took this change for granted. Obviously in the years between the first and the sixth decade of the nineteenth century a real transformation in conceptualization of daily time took place.

The late Edo period manuals for reading Western clock dials open up a window onto the processes involved in this transformation. They show that what we take to be normal and structural about our clock dials, was initially perceived in early nineteenth century Japan as nonsensical and confusing. The two systems of measuring and reading time were incommensurable — *not* in the sense suggested by Thomas Kuhn,[623] but in the original sense of this word, as not being measured by a similar scale and lacking the possibility of being neatly translated one to another. They measured different kinds of temporal entities, focused on different points of the day as temporal anchors, and used different temporal units that were counted completely differently. Yet they were not mutually exclusive, and there was no gestalt switch necessary in order to understand and use both of them, even at the same time. The process of learning the foreign temporal system was difficult and complicated for the Edo-period Japanese, but it *was* possible. By the end of this process, we see how numerous individuals not only learned the alternative way of reading time, but they were also able to use the two systems

[623] Thomas Kuhn, *The Structure of Scientific Revolutions* (University of Chicago Press, 1962).

simultaneously, translating one into the terms of another, finding sense and convenience in both of them. The manuals captured this conceptual process, in which users were guided as to how to distance themselves from the temporal assumptions they held in order to comprehend a different kind of worldview, and how to translate it into familiar terms. They pointed out the various stages of this transition and reveal the problems, which Japanese users of Western watches encountered, and the creative solutions they invented.

But they also indicate that learning how to read a Western watch was not a simple accumulation of theoretical knowledge. Rather, it was through the assistance of material aids — numerical tables, pictorial representations and especially the watches themselves — that the learning was completed. Through the exploration of the physical features of Western watches, the late-Tokugawa Japanese were initiated into the European way of thinking about and measuring time. Dealing with the materiality of these watches, one would practically place oneself into the shoes of Western users, and thus internalize the time-related concepts and time-keeping practices embedded within them by their European creators.

In the late 1860s, therefore, there was hardly any need to convince people of the convenience of Western division of the day because many were already using it, and carried around unmodified Western clocks. Although Fukuzawa Yukichi mocked Tokugawa officials for not knowing how to read the clock, his judgment was unfair. In fact, when we follow Fukuzawa's description, we see that their way of looking at the clock follows exactly the guidelines laid out in the manuals. Perhaps their translation between the systems was not as swift as Fukuzawa's, who used to handle Western watches from his early days in the *Tekijuku* academy of Western sciences, but they were nevertheless able to understand them both. Fukuzawa's own description of the way to read Western watches, on the other hand, is rather

dubious. Even though it seems reasonable from the modern day perspective, it nevertheless fails to create the mediating bridge we saw in other, earlier manuals, so that those who were not yet accustomed to the new system wouldn't be able to learn it by reading Fukuzawa'a description alone. For those who have already gone through the transformation in the conceptualization of hours, this description would have been superfluous. But such was the nature of the whole pamphlet. It was not creating the revolution, but it was only confirming it. The time had already changed.

Conclusion

They say that the times are changing, but how is it possible for time to change? Isn't it the age-old axiom that temporal change is the only constant in life? Yet the "time" that we use is not always the same. We are used to taking our time for granted, relying on its perpetual and invariable flow, and are usually too busy chasing time to actually stop and think about the behaviors associated with its measurement. It is only when we encounter something that we perceive as a temporal incongruity that we notice that time itself has characteristics.

The investigation of the changes in early modern Japanese timepieces, timekeeping practices, and notions of time serves as an example that reveals the contingency of "time." By examining the process through which Western clocks were incorporated into the Japanese temporal landscape, we realize that there is nothing obvious, rational, or necessary about the modern Western notion of "time," which was officially introduced to Japanese society in the 1873 calendrical reform. We find that the very basic assumptions we hold about the movement of time, the measurement of time-units, the handling of timepieces, and even the ways we imagine time, vary dramatically from what was considered to be commonsensical in Edo period Japan. In the Edo period, it was common knowledge that hours change their length throughout the year, but that dawn and sunset always occured on the same hour. By analyzing the Edo period time-related "common sense" we find that it was in fact comprised of a series of historically grounded conventions and tacit assumptions.

Furthermore, the examination of the process in which Western mechanical time-keeping technology was incorporated into the Edo temporal landscape reveals that these conventions and assumptions served Japanese clockmakers and users as tools for the interpretation of mechanical

technology, and that the conversation between this interpretation and changing approaches in astronomy, geography and navigation, created a process in which "time" itself was transformed.

When mechanical clocks first arrived in Japan, they entered a cultural fabric that was quite different from the one in which they were created. Notions of time and timekeeping embedded in them by European clockmakers were not obvious in Japan, and these devices had to be reinterpreted in local terms, and integrated into the changing web of cultural assumptions, imagery, and associations. These clocks were also thrown into a different social reality, yet their subsequent transformation cannot be explained in terms of adaptation to existing practices and social structures alone. As we have seen in this study, the major incongruence between European clocks and Edo culture was the Japanese use of the variable hours, yet there is no social structure or immediate need that can explain the choice to live according to hours of variable length. There was nothing natural about this system — it was neither specifically pre-industrial society nor characteristically "Edo-period." As previously mentioned, eighteenth century Japanese scholars themselves noted that variable hours were used in Japan for centuries. They were a convention — a convention that survived centuries of historical and social changes, which was used across heterogeneous social landscapes. The upholding of this temporal convention happened not because it matched the social reality of all the Japanese for one thousand years, but precisely because various social realities were built into and changed *within* the limits it allowed.

Consequently, the adaptation of European time-keeping technology for use in Edo period Japan has to be explained in terms of its incorporation into the native conventional framework. Similarly, the eventual demise of Japanese clocks was a consequence of a gradual change in the convention itself — a change that was only manifested in the 1873 reform.

"Convention," however, is a too broad of a category in and of itself. It was not only the variable hours that European clocks had to be adapted to, but also the web of interconnected patterns of practice and tacit assumptions that comprised this amorphous convention of time and timekeeping. These patterns and assumptions determined whether "precision" was defined in terms of accuracy of a timekeeper, or whether it was a matter of skillful reproduction of human motion by automata. They stood at the basis of every individual evaluation of the range of time beyond which one would considered to be "late" in various social situations, and allowed one to decide whether an approximation of time should be done to the closest minute, five minutes, fifteen, half an hour, etc. Established patterns of practice and tacit assumptions determined the "proper" placement of the noon hour at the top or the bottom of the dial, and whether the dial had to be round or could be rearranged in alternative shapes. And it was a series of tacit assumptions that shaped the cultural configuration of the relation between time and space — either as correspondence between the names for hours and directions, or as the definition of space in terms of an inseparable continuum of time. These were only some of the innumerous assumptions behind "time," its manifestations and use. And it was through this array of patterns of practice and assumptions that Western time-keeping technology, time-related practices and the notion of time itself were received in Japan.

Mechanical technology of time-keeping was therefore understood in Japan through the lens of both the existing conventions of measuring and depicting time, and the established practices of handling non-mechanical timekeepers. Japanese astronomers learned Western astronomy relying on their existing knowledge of mathematical traditions and Chinese calendrical studies, and were guided by Chinese-language Jesuit treatises, which consciously employed existing Chinese astronomical terminology and methodology in order to explain

foreign, and often otherwise inaccessible concepts. Deciphering Western temporal conventions involved recognizing one's own tacit assumptions about possible ways of measuring and depicting time and conscious distancing of oneself from them. The subsequent familiarization with the Western system was finally achieved through employment of the familiar medium of numerical tables, which were used in order to convert data measured on different scales.

It is clear, then, that when we talk about the transmission of technology, practices, and ideas from one culture to another, it is inadequate to evaluate the result of this transmission from just the point of view of what was transmitted. Rather, we must take into account the background knowledge, tacit assumptions, and existing methods of acquiring knowledge. We can trace the arrival of a certain person, device or book to Japan, yet in order to understand what kind of imprint any of them left on Japanese culture, we must first evaluate the possible methods with which different people approached these objects.

Mechanical clocks, however, were not only interpreted according to an existing set of tacit assumptions. Rather, by entering the Edo temporal and scholarly landscape, clocks were used to establish new approaches and develop new tools for deciphering and analyzing information. Their dynamic mechanical structure inspired people to employ timekeeping devices as a working metaphor for the universe — both the Buddhist and the heliocentric one. The astronomers' use of the pendulum clock facilitated the exploration and the reconceptualization of geographic space, and the hypothetical replication of astronomical time-measuring practices in the course of imaginary open-sea voyages provided a path to finding longitude. Finally, the actual and the hypothetical handling of Western chronometers by Japanese astronomers served as a tool in the process of formulating of the novel concept of universal, mean time.

The history of adoption and adaptation of Western timekeeping technology in Japan, is therefore, not just a story of reception of Western technology and knowledge, but rather a history of evolving patterns of practice, methods of evaluation, and tacit assumptions with which artifacts, techniques, and ideas were conceptualized. The birth, transformation, and subsequent demise of Japanese clocks, as well as the conscious abolition of series of a temporal conventions, should be seen neither through the lens of evolving social conditions that "grew" to fit the Western temporal convention, nor as an accumulation of adequate knowledge, but rather as a process in which the methods with which Western time-keeping system was analyzed and evaluated were gradually transformed.

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Times change, conventions change, new temporal habits emerge and others die out. Yet sometimes, just for a moment, we find tiny pockets of old habits, unchanged by the temporal demands of modern life. After the 1873 calendrical reform, Japanese society consciously embraced Western temporal conventions, developing strict temporal discipline, synchronized communication and perfectly aligned train schedules. In this environment, where every second matters, one might find it surprising to spot signpost announcing that some establishment is open until 25, or 28 o'clock.



Image 24. "Until 28:00 — The Latest (except for Sundays and holidays)"
Sign outside a bar in Tokyo Marunouchi area. Taken by the author in summer 2011.

It is hardly doubtful that in today's Japan there are people, who do not accept the division of the day into twenty-four equal hours. Yet it appears that the longstanding tacit assumption that there are different "times" that require different approaches, some of which could be modified to fit the purpose of a specific time-measuring, survived the temporal revolutions of the late nineteenth and the twentieth century. Of course, there are twenty-four hours a day, but for the twenty-first century Japanese night-life time, it is perfectly rational to say that the bar is open until 28:00 in the morning. If you plan to stay up late, you will understand.

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