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Time Telling through the Ages

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PREFACE

In *the midst of the world war, when ordinary forms of celebration seemed unsuitable, this book was conceived by* Robt. H. Ingersoll & Bro., *as a fitting memento of the Twenty-fifth Anniversary of their entrance into the watch industry, and is offered as a contribution to horological art and science. Its publication was deferred until after the signing of the peace covenant.*

The research work for fact material was performed with devoted fidelity and discrimination by Mrs. Katherine Morrissey Dodge, *who consulted libraries, trade publications, horological schools and authorities in leading watch companies. The following were helpfully kind to her: New York Public Library, New York City; The Congressional Library, Washington, D. C.; Newark Public Library, Newark, New Jersey; The Jewelers' Circular, New York City; Keystone Publishing Company, Philadelphia, Pennsylvania; Mr.* John J. Bowman, *Lancaster, Pennsylvania; Major* Paul M. Chamberlain, *Chicago, Illinois; Hamilton Watch Company, Lancaster, Pennsylvania; Mr.* Henry G. Abbott, *of the Calculagraph Company, New York City, and others*.

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Harry C. Brearley

FOREWORD

It was a moonless night in No Man's Land. A man in khaki stood silently waiting in a frontline trench. In the darkness, his eyes were drawn, fascinated, to the luminous figures on the watch-dial at his wrist. A splinter of pale light, which he knew to be the hour-hand, rested upon the figure 11. A somewhat longer splinter crept steadily from the figure 12.

"Past eleven," he whispered to himself. "Less than twenty minutes now."

To the right and to the left of him, he, now and then, could see his waiting comrades in the blackness of the trench, their outlines vaguely appearing and disappearing with the intermittent flares of distant star-shells. He knew that they, too, were intent upon tiny figures in small luminous circles and upon the steady, relentless progress of other gleaming minute-hands which moved in absolute unison with the one upon his own wrist. He knew, also, that far in the rear, clustered about their guns, were other comrades tensely counting off the passing minutes.

At twenty minutes past eleven, the artillery bombardment would begin and would continue until exactly midnight. Then would come the barrage – the protecting curtain of bursting shells behind which the khaki-clad figure and his companions would advance upon the enemy's trenches – perhaps also upon eternity.

How strangely silent it seemed after the crashing chaos of the last few days! There were moments when the rumble of distant guns almost died away, and he could hear the faint ticking of his timepiece or a whispered word out of the darkness near at hand. He likened the silence to the lull before a storm.

Five minutes thus went by!

In another fifteen minutes, the fury of the bombardment would begin; it would doubtless draw an equally furious bombardment from the enemy's guns.

At twelve-ten plus forty-five seconds, he and his platoon were to "go over the top" and plunge into the inferno of No Man's Land. That was the moment set for the advance – the moment when the barrage would lift and move forward.

The slender hand on the glowing dial stole steadily onward. It was ten minutes after now.

Ten minutes after eleven – just one hour plus forty-five seconds to wait! His thoughts flew back to his home in the great city beyond the sea.

Ten minutes after eleven – why that would be only ten minutes after six in New York! How plainly he could picture the familiar scenes of rushing, bustling life back there! Crowds were now pouring into the subways and surface cars or climbing to the level of the "L's." This was the third – the latest homeward wave. The five o'clock people had, for the most part, already reached their homes and were thinking about their dinner; the five-thirties were well upon their way.

How the millions of his native city and of other cities and towns, and even of the country districts, all moved upon schedule! Clocks and watches told them when to get up, when to eat their breakfasts, when to catch their trains, reach their work, eat their lunches, and return to their homes. Newspapers came out at certain hours; mails were delivered at definite moments; stores and mills and factories all began their work at specified times.

What a tremendous activity there was, back there in America, and how smoothly it all ran – smooth as clock-work! Why, you might almost say it ran *by* clock-work! The millions of watches in millions of pockets, the millions of clocks on millions of walls, all running steadily together – these were what kept the complicated machinery of modern life from getting tangled and confused.

Yes; but what did people do before they had such timepieces? Back in the very beginning, before they had invented or manufactured anything – far back in the days of the caveman – even those people must have had *some* method of telling time.

A bright star drew above the shadowy outline of a hill. At first the man in khaki thought that it might be a distant star-shell; but no, it was too steady and too still. Ah yes, the *stars* were there, even in the very beginning – and the moon and the sun, they were as regular then as now; perhaps these were the timepieces of his earliest ancestors.

A slight rustle of anticipation stirred through the waiting line and his thoughts flashed back to the present. His eyes fixed themselves again on the ghostly splinters of light at his wrist. The long hand had almost reached the figure 4 – the moment when the bombardment would begin.

He and his comrades braced themselves – and the night was shattered by the crash of artillery.

CHAPTER ONE
The Man Animal and Nature's Timepieces

The story of the watch that you hold in your hand to-day began countless centuries ago, and is as long as the history of the human race. When our earliest ancestors, living in caves, noted the regular succession of day and night, and saw how the shadows changed regularly in length and direction as day grew on toward night, then was the first, faint, feeble germ of the beginning of time-reckoning and time-measurement. The world was very, very young, so far as man was concerned, when there occurred some such scene as this:

It is early morning. The soft, red sandstone cliffs are bathed in the golden glow of dawn. As the great sun climbs higher in the eastern sky, the sharply outlined shadow of the opposite cliff descends slowly along the western wall of the narrow canyon. A shaggy head appears from an opening, half-way up the cliff, and is followed by the grotesque, stooping figure of a long-armed man, hairy and nearly naked, save for a girdle of skins. He grasps a short, thick stick, to one end of which a sharpened stone has been bound by many crossing thongs, and, without a word, he makes his way down among the bushes and stones toward the bed of the creek.

Another head appears at the same opening in the cliff – that of a brown-skinned woman with high cheek-bones, a flat nose, and tangled hair. She shouts after the retreating form of the man, and he stops, and turns abruptly. Then he points to the edge of the shadow far above his, and, with a sweeping gesture, indicates a large angular rock lying in the bed of the stream near by. Apparently understanding the woman nods and the man soon disappears into the brush.

The forenoon wears along, and the line of shadow creeps down the face of the canyon wall until it falls at last across the angular rock against which the dashing waters of the stream are breaking. The woman who has been moving about near the cave opening begins to look expectant and to cast quick glances up and down the canyon. Presently the rattle of stones caught her ear and she sees the long-armed man picking his way down a steep trail. He still carries his stone-headed club in one hand, while from the other there swings by the tail the body of a small, furry animal. Her eyes flash hungrily, and she shows her strong, white teeth in a grin of anticipation.

Perhaps it has not been hard to follow the meaning of this little drama of primitive human need. Our own needs are not so very different, even in this day, although our manners and methods have somewhat changed since the time of the caveman. Like ourselves, this savage pair awoke with sharpened appetite, but, unlike ourselves, they had neither pantry nor grocery store to supply them. Their meal-to-be, which was looking for its own breakfast among the rocks and trees, must be found and killed for the superior needs of mankind, and the hungry woman had called after her mate in order to learn when he expected to return.

No timepieces were available, but that great timepiece of nature, the sun, by which we still test the accuracy of our clocks and watches, and a shadow falling upon a certain stone, served the need of this primitive cave-dweller in making and keeping an appointment.

The sun has been, from the earliest days, the master of Time. He answered the caveman's purpose very well. The rising of the sun meant that it was time to get up; his setting brought darkness and the time to go to sleep. It was a simple system, but, then, society in those days *was* simple – and strenuous.

For example, it was necessary to procure a new supply of food nearly every day, as prehistoric man knew little of preserving methods. Procuring food was not so easy as one might think. It meant long and crafty hunts for game, and journeys in search of fruits and nuts. All this required daylight. By night-time the caveman was ready enough to crawl into his rock-home and sleep until the sun and his clamoring appetite called him forth once more. In fact, his life was very like that of the beasts and the birds.

But, of course, he was a man, after all. This means that a human brain was slowly developing behind his sloping forehead, and he could not stop progressing.

After a while – a long while, probably – we find him and his fellows gathered together into tribes and fighting over the possession of hunting-grounds or what not, after the amiable human fashion. Thus, society was born, and with it, organization. Tribal warfare implied working together; working together required planning ahead and making appointments; making appointments demanded the making of them *by* something – by some kind of a timepiece that could indicate *more than a single day*, since the daily position of light and shadows was now no longer sufficient. Man looked to the sky again and found such a timepiece.

Next to the sun, the moon is the most conspicuous of the heavenly objects. Its name means "the Measurer of Time." As our first ancestors perceived, the moon seemed to have the strange property of changing shape; sometimes it was a brilliant disk; sometimes a crescent; sometimes it failed to appear at all. These changes occurred over and over again – always in the same order, and the same number of days apart. What, then, could be more convenient than for the men inhabiting neighboring valleys to agree to meet at a certain spot, with arms and with several days' provisions, at the time of the next full moon? – moonlight being also propitious for a night attack.

For this and other reasons, the moon was added to the sun as a human timepiece, and man began to show his mental resources —*he was able to plan ahead*. Note, however, that he was not concerned with measuring the passage of time, but merely with fixing upon a future date; it was not a question of *how long* but of *when*.

This presumptuous, two-legged fighting animal, from whom we are descended, and many of whose instincts we still retain, began to enlarge his warfare, and thereby to improve his organization. For the sake of his own safety, he learned to combine with his fellows, finding strength in numbers, like the wolves in the pack; or, like ants and bees, finding in the combined efforts of many a means of gaining for each individual more food and better shelter than he could win for himself alone.

For example, it was possible that a neighboring tribe, instead of waiting to be attacked, was planning an attack upon its own account. It would not do to be surprised at night. Sentries must be established to keep watch while others slept, and to waken their comrades in case of need. Our very word "watch" is derived from the old Anglo-Saxon word "waeccan," meaning "wake." And yet people who tried to watch for long at a stretch would be apt to doze. They must be relieved at regular times; it was a matter of necessity, but how could one measure time at night?

Where man has been confronted with a pressing problem he has generally found its solution. Probably in this case the stars gave him a clue. If the sky were clear, their positions would help to divide the night into "watches" of convenient length.

Thus did primitive man begin to study the skies. No longer a mere animal, he was beginning, quite unconsciously, to give indications of becoming a student.

CHAPTER TWO
The Land Between the Rivers

Now we must jump over ages so vast in duration that all of our recorded history is by comparison, the merest fragment of time. During the prehistoric period, known to us only by certain bones, drawings, and traces of tombs and dwellings, and by a few rude implements, weapons, and ornaments, we must think of the human family as developing very, very slowly – groping in the dawn of civilization while it ate and slept, hunted, and fought, and, gradually spread over various regions of the earth.

It was in this interval, also, that man learned the use of fire and the fashioning of various tools. His club gave place to the spear, the knife, and the arrow-head weapons that were made at first by chipping flakes of flint to a sharp edge. Then, as his knowledge and skill slowly increased, he learned to work the softer metals and made his weapons and his tools of bronze. Meanwhile, he was taught, by observing in nature, to tame and to breed animals for his food and use, and to plant near home what crops he wished to reap, instead of seeking them where they grew in a wild state. Thus, he became a herdsman and farmer.

He no longer lived in caves or rude huts, but in a low, flat-roofed house built of heavy, rough stone, and, later, of stones hewn into shape or of bricks baked in the burning sunshine. Stone and clay carved or molded into images, and the colored earth, smeared into designs upon his walls, gave him the beginnings of art. And from drawing rude pictures of simple objects, as a child begins to draw even before knowing what it means to write, primitive man came at last to the greatest power of all – the art of writing.

Through all this age man continued to regulate his expanding affairs by the timepieces of the sky – the sun, the moon, and the stars. He divided time roughly into days and parts of days, into nights and watches of the night, into moons and seasons – determining the latter probably by the migration of birds, the budding of trees and flowers, the falling of leaves and other happenings in nature. But never guessing how greatly interested future generations would be in the way he did things, he has left only a few records of his activities and these have been preserved by the merest accident. The historian and the press-agent were the inventions of later days.

Thus we come down the ages to a date about 4000 B. C. at the very beginning of recorded history, and to one of the most ancient civilizations in the world – that of the region which we now call Mesopotamia. Mesopotamia lies in southwestern Asia between the Tigris and Euphrates Rivers and not far from the traditional site of the Garden of Eden. The name by which we know it comes from the Greek, and means, "The land between the rivers" but the people who dwelt there at the time to which we refer called it the "Land of Shinar."

This is the region in which long afterward – so the Bible tells us – Abraham left his native town, Ur of the Chaldees, to make his pioneer journey to Palestine. This is the land where the great cities of Babylon and Nineveh afterward arose; Babylon, where Daniel interpreted the dream of King Nebuchadnezzar, and Nineveh, whence the Assyrians, the fierce conquerors of the ancient world, "came down like a wolf on the fold" against the peaceful Kingdom of Judah. It is the land where, thousands of years later, the famous Arab capital of Bagdad was built; it is the land of Harun al Raschid and the "Arabian Nights," and the land which the British Army conquered in a remarkable campaign against the Turks and Germans. Mesopotamia is a land of color, brilliant life, wonders and romance. Many students and statesmen believe that it will, in days to come, grow fruitful and populous again, that it will once more be great among the countries of the earth. It is a flat region, with wide-stretching plains. For the most part, there are no hills to limit the view of the skies, and the heavens are brilliant upon starry nights.

In this favored portion of the earth, a high civilization had already been developed in the very earliest days of which we have authentic historic record. The caveman type had long disappeared and had been forgotten; people were already living in well-built cities of brick and stone. Their houses were low and flat-roofed, but the cities were surrounded with high and massive walls to protect them from enemies, and here and there within rose great square towers which were also temples. Perhaps the famous Tower of Babel was one of these, for Babel, of course, is another name for Babylon, and its people are known to have worshipped on the tops of towers, as if, by so doing, they could reach nearer to their gods. The ancient Chaldeans were religious by nature, and because the skies contained the greatest things of which they knew, they identified many of their gods with the sun, the moon, and the stars, and they worshipped these in their temples.

Thus, the sun was the god *Shamash*, the moon was *Sin*, Jupiter was *Marduk*, Venus was *Ishtar*, Mars was *Nergal*, Mercury was *Nebo*, and Saturn was *Ninib*.

In consequence, their priests came to give much of their time to a study of the movements of the stars. These priests, who were shrewd and learned men, discovered a great deal, but they kept their knowledge closely within the circle of their caste. Learning was not for everyone in those days because the priests posed as magicians able to interpret dreams, to explain signs, and to foretell the future. This brought them much revenue; as prophets they were not unmindful of profits.

When we consider that these astrologer-astronomers did not have telescopes or our other modern instruments, it is marvelous to see how many of the laws of the heavenly bodies they really did find out for themselves. Books could be filled, with the story of their discoveries. For example, they observed that the sun slowly changed the points at which it rose and set. During certain months, the place of sunrise traveled northward, and at the same time the sun rose higher in the sky, and at noon was more nearly overhead. At this time, the days were also longer, because the sun was above the horizon more of the time, and then it was summer. During certain other months, the sun traveled south again, and all these conditions were reversed; the days grew shorter and shorter, and it was winter. This is, of course, exactly what the sun appears to do here and now, and we may observe it for ourselves. But these Babylonian priests were the first to study these phenomena and accomplish something by applying their reasoning powers to the facts that presented themselves. They took the time which was consumed in this motion from the furthest north to the furthest south and return, and from that worked out their year.

In order to calculate time, they next devised the zodiac, a sort of belt encircling the heavens and showing the course of the sun, and the location of twelve constellations, or groups of stars, through which he would be seen to pass if his light did not blot out theirs. They divided the region of these twelve constellations into the same number of equal parts; consequently, the sun passing from any given point around the heavens to the same point, occupied in so doing an amount of time that was arbitrarily divided into twelfths.

But they also devised another twelve-part division of the year. They noticed that the moon went through her phases, from full moon to full moon in about thirty days. So one moon, or one month, corresponded with the passage of the sun through one "sign" of the zodiac. Our own word "month" might have been written "moonth," since that is its meaning. That gave them a year of twelve months, each month having thirty days, or three hundred and sixty days in all.

Then from the seven heavenly bodies which they had identified with seven great gods, they got the idea of a week of seven days, one day for the special worship of each god and named for him.

In like manner, they divided the day and the night each into twelve hours; and the hour into sixty minutes and these again into sixty seconds. The choice of "sixty" was not a chance shot or accident; it was carefully selected for practical reasons since these old astronomers were wise and level-headed men. No lower number can be divided by so many other numbers as can sixty. Just look at your watch for a moment and notice how simply and naturally the minutes, divided into fives, fit into place between the figures for the hours, and, because sixty divides evenly by fifteen and thirty, we have quarter-hours and half-hours.

Therefore, we should realize, with a bit of gratitude, that we owe these divisions of time, of which we still make use, to the ancient magician-priests of Babylon and Chaldea, thousands and thousands of years ago.

In doing all this, these early scientists developed at the same time an elaborate system of so-called "magic" by which they pretended to foretell future events and the destinies of men born on certain days. This was an important part of their priestcraft, and probably it was not the least profitable part. In fact, the priests called themselves *magi*, meaning "wise men" in their language, and our word "magic" is derived from "magi."

This *magic*, or prophetic study of the stars, we call *astrology* to distinguish it from the true science of *astronomy*. But mingled with it all, these priests possessed a wonderful amount of genuine scientific knowledge. Their year of three hundred and sixty days was, of course, five days too short, as they presently found out for themselves. In six years, the difference would amount to thirty days, which was exactly the length of one of their months. So they corrected the calendar very easily by doubling the month Adar once in six years. Thus, every sixth year contained thirteen months instead of twelve; that was the origin of the leap-year principle which we still use, although more accurately. It can be seen that, with all their superstition and their befooling of other people, the priests themselves were by no means ignorant; they were really keen observers.

This calendar, by which we still measure the years and the seasons, is so interesting a thing that it is worth while to pause for a moment in our story in order to trace out its later development. The Babylonian calendar remained practically the same up to the time of Julius Caesar, only a few years before the Christian Epoch. The names of the months had naturally been changed into the Latin language; and the Romans, instead of doubling a whole month, had come to add the extra five days to several months, one day to each. That is the reason for some of our months having thirty-one days.

When Caesar was Dictator of Rome, it had become known that the year of exactly 365 days was still a little too short. It should have been 365¼. So Caesar in reforming the calendar, provided that the first, third, fifth, seventh, ninth, and eleventh months should be given thirty-one days each, and that the others should have thirty days, except in the case of February which should have its thirtieth day only once in four years. A little later, his successor, the Emperor Augustus, after whom the month of August is named, decided that *his* month must be as long as July, which was Julius Caesar's month. Therefore, he stole a day from February and added one to August; then he changed the following months by making September and November thirty-day months and giving thirty-one days to October and December.

The Julian calendar, with these changes by Augustus, remained in use until the year A. D. 1582, nearly a century after the discovery of America. Then it was learned that the average year of 365¼ days was still not exactly right according to the motion of the earth around the sun. The exact time is 365 days, 5 hours, 48 minutes and 46 seconds, being 11 minutes and 14 seconds less than 365¼ days. When, therefore, we add a day to the year every four years, as Caesar commanded, we are really adding too much. This excess was corrected by Pope Gregory XII in 1582, when he changed the calendar so that the last year of a century should be a leap-year only when its number could be divided evenly by 400. Thus, 1700, 1800, and 1900 were not leap-years, though the year 2000 will be. This new calendar, which is the one now generally in use in most of the world, is known as the Gregorian calendar.

Thus the plan and principle of the calendar, as well as our smaller divisions of time, in spite of the small changes by Caesar and Gregory, have remained from the Babylonian days down to the present; and we have done nothing to their system in all these thousands of years, except, incidentally to correct it.

Only once in history have the measures of the ancient calendar been set aside. That was in France at the time of the Revolution, when the French people, in their passionate hatred of all the traditional things that reminded them of their past sufferings, invented a new calendar, in which they changed the names of months and days, and counted the years from 1792, the first of their liberty. They also abolished all Sundays and religious festivals, and divided the day into ten hours. This played havoc with time-keeping, and caused great confusion. Watches and clocks were made with one circle of numbers for the new hours, and another, within, on which were shown the old hours which people could understand. But this complication lasted only a few years, for the traditional system was soon restored.

To return again to the era of the first calendar. While the wise men of Mesopotamia were engaged in mingling science and mystery, another civilization, the Egyptian, was developing upon the banks of the Nile and passing through much of the same stages. In due course the Persians conquered both Mesopotamia and Egypt and absorbed their knowledge. Still later the wonderful Greek nation combined astronomy with mathematics in a way which makes us wonder to this day. This is the way in which civilization has grown. Race after race, during century after century has added its new knowledge and discoveries to that which has been learned before. It is interesting to note that the astronomy of the Babylonians appears to have been paralleled independently by other ancient civilizations between which there was no apparent possibility of intercourse. The Chinese in the East and the Aztecs of Mexico, on the other side of the world, invented practically the same astronomical instruments as the Babylonians and made similar discoveries. All methods of indicating time have been steps upon the long road which has led to the making of modern timepieces.

The progressive Greeks did not permit knowledge to be monopolized by the priesthood and probably their common people knew more about the stars than most of the population of America do to this day. Sailors possessed no compasses, but they voyaged very skilfully with the guidance of the stars, while farmers, lacking our modern weather-reports and crop-bulletins, learned to govern their planting and harvesting by the positions of the heavenly bodies.

In one sense, this is time-telling and in another it is not, but our ideas of time and astronomy have always been so closely associated that it is hard to think of one apart from the other. This is because the movements of the earth, which produce night and day and the changes of the seasons, are our supreme court of time, our final standard for its measurement. And since we cannot see the earth move, we judge of its motion by the apparent movement of the heavenly bodies, just as we realize the movement of a train by watching the landscape rush past us as we go.

Some of the great Greek scientists, by the way, had even learned to foretell eclipses of the sun. According to Herodotus the one which occurred on May 28th, in the year 585 B. C., was predicted by Thales of Miletus, one of the famous "Seven Wise Men." This event was also celebrated because of another interesting association; it stopped a battle between the armies of the Medes and the Lydians. Perhaps we can guess at what happened. Undoubtedly the eclipse was interpreted by the armies as a sign of divine anger, for the ancients identified many of the forces and objects of nature as gods, and Phoebus Apollo, who it was believed daily drove his flaming chariot across the sky, was the great divinity of the sun. Furthermore, these gods were very apt to meddle with happenings upon the earth, particularly with wars, as anyone who has read the "Iliad" will recall.

Imagine, then, the two armies about to go to battle when suddenly something appeared to go wrong with the sun. There to their amazement, in a cloudless sky, a dimming shadow touched the edge of the sun's shining disk and began slowly to blot it out. The warriors forgot to fight each other and stared in terror at the sky. The sun dwindled to a crescent; a weird twilight fell upon the earth. Finally, the last thread of brightness disappeared leaving a dull circle in the sky, surrounded by faint bands of light. The gloom of night fell upon the ground. Birds and animals went to their rest.

No further evidence was needed by the superstitious and frightened soldiers. It must be true that Phoebus Apollo was grievously angered, and they forthwith laid down their arms. The sun god, of course, soon showed his approval of this action by coming back into the sky.

This is only one of many tales which might be told to show the state of superstition in those days. Learning, then, was confined to the few, and in many instances was used to mystify or terrorize the mass of the people and thus keep them submissive. At best, new ideas were slow to grow or to be believed.

For example, Pythagorus, the great Greek philosopher of the sixth century B. C., believed the earth to be a globe, but it was not until Columbus discovered America – twenty centuries later – that people generally began to know that it was not flat. Even in these modern days of the public school, the press, the telephone, the telegraph, the wireless and other means for the wide-spread distribution of knowledge, how slowly does truth find its way to acceptance! To this day, superstition is by no means dead.

Even Mark Twain, who scoffed at superstition all his life, often said that, as he came into the world with Halley's Comet, in the year 1835, so he expected to die in 1910, the year of the comet's next appearance. Strangely enough, his half-jesting prophecy was fulfilled, for he really did die in that year.

Astronomers to-day can figure out in advance what is to happen in the heavens with an exactness which would have seemed magical in olden times, and is hardly less astonishing even now. Their power is largely due to improved scientific instruments, proficiency in mathematics and greater accuracy in the measurement of time. Not only is the date of an eclipse of the sun now known in advance, but so also is the exact path of the shadow across the world, and the instant of its appearance in any given place.

We now have glanced briefly at a few of the features of early humanity's dependence upon the clocks of nature and the way in which they influenced its manner of life. We still depend upon these great primeval timepieces and we do it for the most part unconsciously, for our master clocks must still be set by the motion of the heavenly bodies.

That motion, which now we know to be really the revolution of our earth, is still the legislator and supreme court of time. But we have learned to make and carry everywhere a wonderful machine, whose revolving wheels and pointing hands keep tryst with the stars in the heavens and move to the rhythm of wheeling worlds. And so familiar is this talisman of man's making, that we forget to look beyond it or think of time at all save as the position of the hands upon the dial.

We carry with us carelessly a toy which tells tales upon the solar system – our watch is a pocket universe.

CHAPTER THREE
How Man Began to Model After Nature

We now have reached a point far ahead of our story and must take a backward step. We have been seeing man as a mere observer of nature; but man doesn't stop with nature as he finds it – his man-brain drives him forward; he must make improvements of his own. Animals may live and die and leave no trace save their bones, which for the most part soon disappear, but man always leaves traces behind him. He has always interfered with nature, or rather has modeled after nature, seeing in her work the revelations of principles and laws that he might utilize in varying ways for his own benefit and progress. Our material civilization is built up from the accumulated results of all this study and control of nature by hundreds of millions of busy brains and hands, through tens of thousands of years.

Here we are, then, living, in a sense on the top of the ages of human history, like the dwellers on a coral island. Hundreds of generations have toiled to raise the vast structure for us, like the little coral "polyps" which build their own lives into the mass, yet we take it all as a matter of course and rarely give a thought to the marvelous ways by which it has come about. You may have just glanced at your watch. To you, perhaps, a watch has always seemed merely a small mechanism which was bought in a store. That is true, and yet – remember this – the first manufacturer who had a hand in producing that watch for you, may have been a caveman.

In order to appreciate this development, let us return, therefore, for another rapid view of prehistoric times; life in its crudest form – one day much like another – a scanty population, huddled in little groups in places naturally sheltered – the simplest physical needs to be provided for – little thought of the past or care for the future – time-reckoning reduced to the single thought of appointment – no reason for measuring intervals – in these and other respects antiquity presented the greatest possible contrast to our complicated modern life.

The long-armed man of our first chapter noticed that as the sun moved, the shadows of the cliff also moved, as did all other shadows. As he formed habits of regularity, it was natural for him to perform a certain daily act when, perhaps, the shadow of a certain tree touched upon a certain stone. This would be a *natural* sun-dial.

But a thinner, sharper shadow would be easier to observe; suppose, therefore, that some successor to the long-armed man set up a pole in some open space and laid a stone to mark the spot where the shadow fell when the sun was highest in the heavens. That would be an *artificial* sun-dial —*a device deliberately planned to accomplish a certain purpose*. The man who first took such a step was probably the first manufacturer who had a hand in supplying you with your watch. The shaggy mammoth, the terrible saber-tooth tiger and the eohippus, the small ancestor of our modern horse, must have been familiar sights when time-recording at the hands of some rude, unconscious inventor thus began the long story of its development.

One stone reached by the moving shadow would mark only one point of time each day. Why not place two stones, three stones, or even more and get more markings? Such a procedure would be more useful because it would indicate the time of other happenings in the course of the day. The sun would pass across the skies and the shadow must travel around the pole. What more natural than to place the stones in a circle and get a series of these markings?

Of course, as the ages passed, life became more complex – not complex as we would consider it to-day, but, as compared with its rude beginnings. New habits were formed, new needs developed, new activities were undertaken at different periods.

Here, then, was the sprouting of modern civilization – the beginning of that specializing of each man in his own particular direction that has carried the world to its present high state of expertness in so many fields. Slowly steadily, and inevitably this principle of specialization has been developed. With the increase of laws, for example, certain men came to give them special study and then to sell their knowledge and skill to other men who had no opportunity for such study. In course of time, the aggregation of laws became so great that these lawyers were forced to specialize among themselves; to-day, therefore, we find a number of classes of law specialists. The same thing is true of doctors who have limited their practise until we find those who treat the eye only, or the lungs, the stomach, or the teeth. Even the treatment of the teeth has been subdivided, some dentists limiting themselves to extraction and some of them even to the treatment of a single disease of the gums.

Engineering, too, has branched like a tree and the branches have branched again and yet again. Electrical engineering has come to be divided into so many departments that telephone companies employ specialists in many branches of the engineering profession.

We find the same conditions in any field of thought or activity – all commercial and industrial life is divided and subdivided; labor is specialized; writing is specialized; teaching is specialized; even warfare has become a contest between many kinds of trained specialists, each employing the tools of his trade; and every man's outlook upon life is directed chiefly toward the particular corner of the particular field that he has fitted himself to occupy.

The first step toward this complex condition of the modern world was taken when each man stopped getting his own food, making his own weapons, and providing for all his individual wants without dependence upon others. When he learned to exchange that which he could best produce for that which some other man had learned to make better than he, the human race unconsciously turned away from the status of the birds and the beasts and began the long, slow upward climb that history records.

It was, then, through trade, barter and exchange that man began to acquire the manners of civilized life. Trade itself became a specialized activity, and dealers who did nothing but buy and sell, but themselves produced no material goods, found that a special calling was rightfully theirs. The modern merchant is the heir of one of the first "specialists" in human activity, and the misunderstood work of the so-called "middleman" is one of the bases of modern civilization – a necessary and honorable calling.

Civilization is a thing of the spirit, but it has the support of material things and it has been truly said that the degree of a people's civilization can be measured by the multiplicity of its needs. The savage is content with food, shelter and a covering for his body, but every step in civilization's progress has a more and more complex material accompaniment, and these interwoven relationships of modern life in which the question of time is a most important factor can only be sustained through the use of accurate time-measure. In other words, modern civilization leans upon the watch.

But here again we have run somewhat ahead of our story which, as a matter of fact, had only reached the point of primitive sun-dials. But this anticipation will be excused because of the importance of emphasizing that the growing interdependence of human relations had made it necessary to take into account the convenience of a greater and greater number of people, and this involved closer and closer time-recording in smaller divisions of time by more exact methods.

The sun-dial underwent so many changes that a volume would be needed to describe them all. For example, it was found that the shadow of an upright stick or stone varied from day to day, because, as we have already noticed, the sun rises farther north in summer in the northern hemisphere than it does in winter. So the mark for a certain hour would change as the season changed, and the dial would not indicate time accurately.

Berosus, a Chaldean historian and priest of Bel, or Baal, a god of the old Babylonian, lived about the year 250 B. C., and hit upon a very ingenious way of solving this difficulty. He made the dial hollow like the inside of a bowl. Into this the shadow was cast by a little round ball or bead at the end of a pointer that stood horizontally out over the bowl.

Now the sky itself is like a great bowl or inverted hemisphere, and, howsoever the sun moved upon it, the shadow would move in the same way upon the inside of the bowl or hemisphere. And by drawing lines in the bowl, similar to the lines of longitude upon the map, the hours could be correctly measured. The "Hemicycle of Berosus," as it was called, remained in use for centuries and was the favorite form of sun-dial all through the classic period of Greece and Rome. Cicero had one at his villa near Tusculum, and one was found, in 1762, at Pompeii.

But the hemicycle was not easy to make unless it were fairly small, and, if small, it was not very easy to read. You can see that a shadow which traveled only a few inches in a whole day would move so slowly that one could hardly see it go. And the shadow of a round ball is not a clear sharp-pointed thing like the hand of a watch, whose exact position can be seen however small it may be. Besides, the ancients were not very particular about exact timekeeping. They had no trains to catch, and in their leisurely lives convenience counted for more than doing things "on the minute." So they still continued using the upright pointer which the Greeks called the *gnomon*, meaning "the one who knows."

"Cleopatra's Needle," and other Egyptian obelisks may also have been used as huge gnomons to cast their shadows upon mammoth dials, for they were dedicated to the sun. With an object of such great size the shadow would move rapidly enough to be followed easily by the eye. But of course its motion would be irregular because of the flat surface of the dial. The word "dial," by the way, comes from the Latin *dies* meaning "day," because it determined the divisions of the day.

Then there was applied the idea of making the shadow move over a hollow space, such as a walled courtyard, going down one side, across, and up the other side as the sun went up, across and down the sky. Sometimes light was used instead of shadow, the place being partially roofed over and a single beam of light being admitted through a small hole at the southern end. Men kept track of the motion of this beam as it touched one point after another during the day.

Do you remember the miracle of the dial of Ahaz, mentioned in the Bible? Hezekiah the king was sick and despondent, and would not believe that he could ever recover from his illness or prevail against his enemies. So the prophet, Isaiah, in an effort to comfort the royal sufferer, made the shadow return backward ten degrees upon the dial of Ahaz, as a sign from heaven that his prophecy of the king's future recovery was true. You will find the story in Isaiah, Chapter thirty-eight.

This dial of Ahaz was probably a curved flight of steps rising like the side of a huge bowl at one end of the palace courtyard, with either a shadow cast by a pointer overhead or a beam of light admitted through an opening. It can be seen that this and similar great dials were applications of the hemicycle idea on a large scale.

According to our chronology, the dial of Ahaz must have been built during the eighth century, B. C. Although the sun-dial period was, of course, many hundreds of years older than this, yet the story of this Hebrew king and prophet is the first authentic reference to a sun-dial which has been discovered.

However, the final improvement of the dial was made when it was discovered that by slanting the pointer, or gnomon, exactly toward the north pole of the sky – the point where the north star appears at night – the sun's shadow could be cast upon a flat surface with accurate results in indicating time.

This may sound simple, but if you will look at a sun-dial such as may still be found in gardens, you will see that the lines of the hours and minutes are laid out on certain carefully calculated angles; you will realize that people had to acquire considerable knowledge before they were capable of making such calculations. The whole subject of dial-making is so complicated that, in 1612, there was published a big book of eight hundred pages on the subject.

The angles of the lines of the sun-dial must be different for different latitudes. It took that strong-arm race of ancient times, the Romans, a hundred years to learn this fact. The Romans, at this time, were developing their civilization from the shoulders downward, while the Greeks and some of the Greek colonies developed theirs from the shoulders upward. Rome was a burly power, with powerful military muscles. Whatever it wanted it went out and took at the point of the sword, as some nations have endeavored to do in latter days. Thus, the city of Rome became a vast storehouse of miscellaneous loot – the fruit of other men's brains and hands.

Some conqueror of that day took back with him a sun-dial from the Greek colony of Sicily. This was set up in Rome, where nobody realized that even the power of Rome's armies was not able to transplant the angle of the sun as it shone upon Sicily far to the southward. It was nearly one hundred years before these self-satisfied robbers found that they had been getting the wrong time-record from the stolen instrument. Thus, the original owners had a form of belated revenge, could they but have known it.

One of the largest of all the sun-dials was the one set up by the Roman Emperor Augustus when he returned from his Egyptian wars bringing with him an obelisk not unlike the one which now stands near the Metropolitan Museum of Art in Central Park, New York City. If you can imagine this Egyptian obelisk, with its strange hieroglyphic characters upon its four sides, surrounded by a great dial with the figures of the hours marked upon its surface, you will get an idea of the size of this huge timepiece. However, it was probably more picturesque than valuable as a time-keeper.

There is an important difference between clocks and sun-dials, aside from the self-evident one of the difference in their construction. Clock-time is based on what is called "mean time." If we study the almanac table of times of sunrises and sunsets, and count the number of hours from sunrise of one day to sunrise of the next, we find it is rarely exactly twenty-four hours, but usually a few minutes more or less, while the average for the whole year is twenty-four hours. The clock is constructed to keep uniform time based on this average length of day.

The sun-dial time marks "apparent time," the actual varying length of each day. The sun-dial time, therefore, is nearly always some minutes ahead or behind that of a clock, the greatest discrepancy being about sixteen minutes for a few days in November. There are, however, four days in the year when the clock and the sun-dial agree perfectly in the time they indicate. These days are April 15th, June 15th, September 1st, and December 24th.

When in the eighteenth century clocks and watches began to come into wide-spread use sun-dials fell into neglect, except as an appropriate bit of ornament in gardens. At Castletown, in the Isle of Man, is a remarkable sun-dial with thirteen faces, dating from 1720.

It was usual to place on sun-dials appropriate mottoes expressing a sentiment exciting inspiration or giving a warning to better living. A dial that used to be at Paul's Cross, London, bore an inscription in Latin, which translated means, "I count none but the sunny hours." In an old sweet-scented garden in Sussex was a sun-dial with a plate bearing four mottoes, each for its own season: "After darkness, light;" "Alas, how swift;" "I wait whilst I move;" "So passes life." Sometimes short familiar proverbs were used like: "All things do wax and wane;" "The longest day must end;" "Make hay while the sun shines."

It is told of Lord Bacon, that, without intending to do so, he furnished the motto borne by a dial that stood in the old Temple Gardens in London. A young student was sent to him for a suggestion for the motto of the dial, then being built. His lordship was busy at work in his rooms when the messenger humbly and respectfully made his request. There was no answer. A second request met with equally oppressive silence and seeming ignorance of even the existence of the speaker. At last, when the petitioner ventured a third attack on the attention of the venerable chancellor, Bacon looked up and said sharply: "*Sirrah, be gone about your business*." "A thousand thanks, my lord," was the unexpected reply, "The very thing for the dial! Nothing could be better."

We see that the principle of the sun-dial has been recognized and utilized for many centuries; indeed, we still find sun-dials placed in gardens and parks although we rarely take the trouble to look to them for the time. Like the dinosaur and the saber-toothed tiger, they have had their day. They have been forced to give way to devices that overcame some of their objections; therefore we must not linger too long upon what is, after all, a closed chapter in the history of time-recording.

CHAPTER FOUR
Telling Time by the Water-Thief

Now we must take another backward step of thousands of years. In considering the subject of time-recording, it seems necessary to wear a pair of mental seven-league boots, for we must often pass back and forth over great periods at single strides. While men were still improving the sun-dial, its disadvantages were already recognized and search was being made for some other means of telling time.

Suppose, for example, that one had only a sun-dial about the house; how would one be able to tell time after sunset or on a dark day? How would one know the hour if he were surrounded by tall buildings or a thick growth of trees? And it might be very necessary to tell time under any of these conditions.

Then, again, merely as a question of accuracy, the sun-dial was not always reliable. It would get badly out of the way if used by travelers, since different markings were needed for different latitudes. While on shipboard the motion of the waves would cause the shadow to swing around in the most bewildering manner. Even under ideal conditions it was never absolutely exact, because the apparent motion of our steady-gaited old sun is not quite as dependable as most of us imagine.

Astronomers find that they must allow for what they call "equation of time" in order to make their calculations come out true. The question need not be discussed at this point, but it can be seen that, as humanity left its earliest care-free days and began to get busy, and hurried and anxious over its affairs, it came to feel that after all the sun-dial was not altogether sufficient for its needs.

For this reason we are now taking a third big backward step, returning, this time, not to the caveman but to ancient Babylon and Egypt, probably not less than twenty-seven hundred years ago and possibly much longer. In this way we meet the *clepsydra*.

The clepsydra was an interesting instrument, and it had an interesting name, which meant the "thief of water" and came from two Greek words meaning "thief" and "water"; you can trace this in our words "kleptomaniac" and "hydrant." We shall now examine a timepiece that was much more nearly a machine than was the simple shade-casting sun-dial.

The original idea was simple enough. At first, it was merely that of a vessel of water, having a small hole in the bottom, so that the liquid dripped out drop by drop. As the level within the jar was lowered, it showed the time upon a scale. Thus, if the hole were so small and the vessel were so large that it would require twenty-four hours for the water to drip away at an absolutely steady rate, it may be seen that the side of the vessel might easily have been marked with twenty-four divisions to indicate the hours. It may also be seen that the water would drip as rapidly at night or in shadow as in sunlight. And the clepsydra could be used indoors, which the sun-dial could not, although it required attention in that it must be regularly refilled and the orifice must always be kept completely open, because the slightest stoppage would retard the rate of dripping and the "clock" would run slow.

The sun, which, with the other heavenly bodies, had therefore been the sole reliance of the human race in its time-reckoning could now be ignored and the would-be timekeeper called to his aid another mighty servant from the forces of nature – that of gravitation.

The most interesting human fact, however, about the clepsydra is that it involved an entirely different conception of the marking of time. Now it was not so much a question of *when* as of *how long*. A good sun-dial set in a proper position would always indicate three o'clock when it *was* three o'clock, but the clepsydra might do no such thing. It would merely show how many hours had elapsed since last it was filled, and the steady drip, drip, drip of the escaping water could – and did – lower the surface quite as evenly at one time of day as at another.

We have already seen that the first purpose in marking time was merely for making appointments, but the clepsydra shows that, with its invention, mankind had already made some progress toward a new point of view. One important factor in this change was the very practical need of telling time at night, in stormy weather, or indoors, where the sun-dial could not be used. The clepsydra, on the other hand, worked equally well at any hour or place, and in all sorts of weather.

Nevertheless, it, too, proved to have certain faults. After a time, people noticed the interesting fact that water ran faster from a full vessel than from one which was nearly empty; this was, of course, because of the greater pressure. Since such a variation interfered with calculations, they hit upon the idea of a double vessel; the larger one below containing a float which rose as the vessel filled, thus marking the hours upon the scale, and the smaller one above, the one from which the water dripped, being kept constantly filled to the point of overflow.

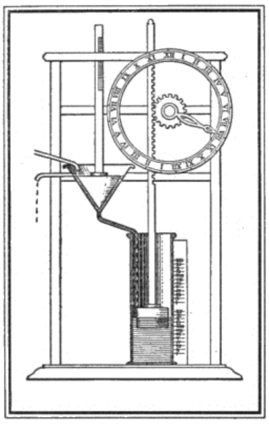
This improved form of clepsydra opened a field of fascinating possibilities in time-recording —*it gave the chance to make use of a machine*. There is, perhaps, no more interesting point in studying human development than to see the steady, inevitable way in which mankind from its cave-dwelling days has tended toward machinery. Roughly, this progress may be characterized as of three stages.

First. Primitive man – an upright-standing animal, naked, unarmed, weak as compared with some creatures, slow as compared with others, clumsy as compared with still others – a creature with many physical disadvantages, but with the best brain in the animal kingdom.

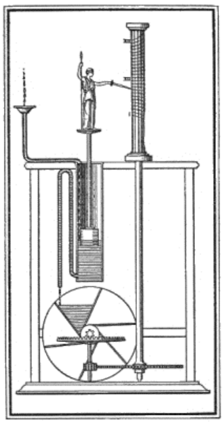
Second. The tool-using man, who had begun to grasp weapons and to fashion implements, thus supplementing his natural abilities by artificial means.

Third. The machine-making man, who has fashioned to himself a mechanical "body" of incredible powers – that is to say, he has learned to intensify his own powers through artificial means which he has invented, as when he made the telescope to give himself greater vision; he has made inventions by means of which he can outrun the antelopes, outfly the birds, outswim the fishes, outgaze the eagles, and overmatch the elephants in sheer physical force – he can turn night into day, can send his voice across the continent, can strike crushing blows at a distance of many miles and can carry the movements of the stars in his pocket. Some phases of this third stage were foreshadowed when man first applied wheels and pulleys to his clepsydra.

Here, then, was water steadily raised or lowered by means of uniform dropping; here was a float whose motion was controlled by that of the water; here, in fact, was water-power with a means for applying it. Attach a cord to the float, cause it to turn a wheel by use of the pulley-principle, and the motion of the wheel would indicate the time. Still better, rig up a turning-pointer, increase its speed through the use of toothed gear-wheels, place it in front of a stationary disk divided to indicate the hours, and now the apparatus looked not unlike a modern clock. Or attach a bell and let it be caused to ring at a certain point in the motion – what was that but an alarm-clock? Ctesibus of Alexandra was the one who is believed first to have applied the toothed wheels to the clepsydra and this was about 140 B. C.



Clepsydrae were expensive of course; accurate mechanical work was never cheap until modern times. Cunning craftsmen spent their time upon costly decorations, and these water-clocks became triumphs of the jeweler's art, a gift for kings. Therefore, like the sun-dial, they drifted into Rome – that vast maelstrom of the ancient world. Imagine a great walled city of low flat-roofed buildings, with fronts and porches of great columns, a town mostly of stone and much of it of marble, gleaming white under the bright Italian sun, the streets thronged with men in tunics and togas and here and there some person of importance driving by, standing erect in his chariot drawn by four horses harnessed abreast. And statues everywhere, in the streets and about the buildings and in cool courtyards and gardens among green leaves. The ancients thought of sculpture as an outdoor thing, and where we have one statue in the streets or public places of our cities, they had a hundred. We treasure the remains of them as artistic wonders in our museums, but they put them indoors and out as common ornaments, and lived among them.



Presently we hear of the clepsydra being used in Roman law courts by command of Pompey, to limit the time of speakers. "This," says one writer of the day, "was to prevent babblings, that such as spoke ought to be brief in their speeches." It is not difficult to picture some pompous and tiresome togaed advocate, rolling out sonorous Latin syllables as he cites precedents and builds up arguments, while an unseen dropping checks the time against him, and to hear his indignant surprise – and the chuckles of his auditors – when the relentless water-clock cuts him short in the middle of some period. Martial, the Latin poet, referring to a tiresome speaker who repeatedly moistened his throat from a glass of water during the lengthy speech, suggested that it would be an equal relief to him and to his audience, if he were to drink from the clepsydra. But Roman lawyers were not guileless, and sometimes, so we are told, they tampered with the mechanical regulation or else introduced muddy water, which would run out more slowly.

This suggests one of the difficulties of the clepsydra. Still more serious was the fact that it would freeze on frosty nights. There were no Pearys among the ancient Romans; polar exploration interested them not at all; but they did spread their conquests into regions of colder weather – as when Julius Caesar mentions using the clepsydra to regulate the length of the night-watches in Britain. His keen mind noted by this means that the summer nights in Britain were shorter than those at Rome, a fact now known to be due to difference of latitude.

As late as the ninth century, a clepsydra was regarded as a princely gift. It is said, that the good caliph, Harun-al-Raschid, beloved by all readers of the "Arabian Nights," sent one of great beauty to Charlemagne, the Emperor of the West. Its case was elaborate, and, at the stroke of each hour, small doors opened to give passage to cavaliers. After the twelfth hour these cavaliers retired into the case. The striking apparatus consisted of small balls which dropped into a resounding basin underneath.

The clepsydra appears to have been used throughout the Middle Ages in some European countries, and it lingered along in Italy and France down to the close of the fifteenth century. Some of these water-clocks were plain tin tubes; some were hollow cups, each with a tiny hole at the bottom, which were placed in water and gradually filled and sank in a definite space of time.

When the clepsydra was introduced from Egypt into Greece, and later into Rome, one was considered enough for each town and was set in the market-place or some public square. It was carefully guarded by a civic officer, who religiously filled it at stated times. The nobility of the town and the wealthy people sent their servants to find out the exact time, while the poorer inhabitants were informed occasionally by the sound of the horn which was blown by the attendant of the clepsydra to denote the hour of changing the guard. This was much in the spirit of the calls of the watchmen in old England, and later in our New England, who were, in a way, walking clocks that shouted "Eleven o'clock and all's well," or whatever might be the hour.

Allowing for the fact that the clepsydra was none too accurate at the best and that its reservoir must occasionally be refilled, it can be seen that this early form of timepiece, having played its part, was ready to step off the stage when a more practical successor should arrive.

With one of its earliest successors we are familiar.

CHAPTER FIVE
How Father Time Got His Hour-Glass

Every now and then one sees a picture of a lean old gentleman, with a long white beard, flowing robes, and an expression of most misleading benignity. In spite of his look of kindly good humor, he is none too popular with the human race and his methods are not always of the gentlest. In one hand he carries the familiar scythe, and, in the other, the even more familiar hour-glass. By this we may assume that he began to be pictured in this way while the hour-glass was still in common use.

The principle of the hour-glass is so similar to that of the clepsydra, and its first use was so early, that it is somewhat of a misnomer to speak of it as a successor. About the only justification that can be made is that the clepsydra has long disappeared, while the sand-glass – if not the hour-glass – is still sold in the stores for such familiar uses as timing the boiling of eggs, the length of telephone-conversations, and other short-time needs.

Nothing could be much simpler than the hour-glass, in which fine sand poured through a tiny hole from an upper into a lower compartment. It had none of the mechanical features of the later clepsydræ; it did not adjust itself to astronomical laws like the perfected sun-dials; it merely permitted a steady stream of fine sand to pass through an opening at a uniform rate of speed, until one of the funnel-shaped bowls had emptied itself – then waited with entire unconcern until some one stood it upon its head and caused the sand to run back again.

However, it possessed some very solid advantages of its own. It would not freeze; it would not spill over; it did not need refilling; it would run at a steady rate whether the reservoir were full or nearly empty; it could be made very cheaply, and there was nothing about it to wear out.

A water-clock might be of considerable size but a sand-clock, since it required turning, must be kept small, and an *hour-glass*– a size small enough to carry – became popular, although its use was correspondingly limited. Thus, it naturally was assigned to Father Time to be carried before watches were available. A sun-dial simply would not answer this purpose, since the old gentleman works by night as steadily as by day.

How old is the sand-glass?

We do not know definitely, but it is said to have been invented at Alexandria about the middle of the third century B. C. That it was known in ancient Athens is certain, for a Greek bas-relief at the Mattei Palace in Rome, representing a marriage, shows Morpheus, the god of dreams, holding an hour-glass. The Athenians used to carry these timepieces as we do our watches.

Some hour-glasses contained mercury, but sand was an ideal substance, for, when fine and dry, it flows with an approximately constant speed whether the quantity is great or small, whereas, liquids descend more swiftly the greater the pressure above the opening.

Hour-glasses were introduced into churches in the early sixteenth century when the preachers were famous for their wearisome sermons. The story is told of one of these long-winded divines who, on a hot day, had reached his "tenthly" just as the restless congregation were gladdened to see the last grains of sand fall from the upper bowl. "Brethren," he remarked; "Let us take another glass," and he reversed it – "Ahem, as I was saying – " And he went on for another hour.

Other preachers, more merciful, used a half-hour glass and kept within its limits. Many churches were furnished with ornamental stands to hold the glass. These timekeepers lingered along in country churches for many years, but ceased to be in anything like general demand after about 1650.

For rough purposes of keeping time on board ship, sand-glasses were employed and it is curious to note that hour and half-hour glasses were used for this purpose in the British navy as recently as the year 1839.

The very baby of the hour-glass family was a twenty-eight second affair which assisted in determining the speed of the vessel. The log-line was divided by knots, at intervals of forty-seven feet, three inches, and this distance would go into a nautical mile as many times as twenty-eight seconds would go into an hour. When the line was thrown overboard the mariner counted the number of knots slipping through his fingers while his eyes were fixed on the tiny emptying sand-glass, and in this way so many "knots" an hour denoted the ship's speed in miles.

In the British House of Commons, even at the present time, a two-minute glass is used in the preliminary to a "division," which is a method of voting wherein the members leave their seats and go into either the affirmative or negative lobbies. While the sand is running, "division-bells" are set in motion in every part of the building to give members notice that a "division" is at hand.

It was an ancient custom to put an hour-glass, as an emblem that the sands of life had run out, into coffins at burials.

Another early means of recording time applied the principle of the consumption of some slow-burning fuel by fire. From remote ages, the Chinese and Japanese thus used ropes, knotted at regular intervals, or cylinders of glue and sawdust marked in rings, which slowly smoldered away. Alfred the Great, that noble English king of the ninth century, is said to have invented the candle-clock, because of a vow to give eight hours of the day to acts of religion, eight hours to public affairs, and eight hours to rest and recreation. He had six tapers made, each twelve inches long and divided into twelve parts, or inches, colored alternately black and white. Three of these parts were burned in one hour, making each inch represent twenty minutes, so that his six candles, lighted one after the other by his chaplains, would burn for twenty-four hours.

The Eskimos also, through the long arctic night have watched the lamp which gives both light and heat to their cold huts of snow. But all these are no more than crude conveniences, whose irregularity is evident, and there is likewise no need to do more than call attention to the effect upon fire in any form, of wind or dampness in the air. The Roman lamp-clock sheltered from the weather was the best of them all, and was the only one which long continued in civilized use.

Our chief interest in all such devices comes from the touch of poetry still remaining in the tradition of the sacred flame which must be kept forever burning, and in association of life and time with fire, in such parables as that of the Wise and Foolish Virgins. There is a reminder of this old time-keeping by fire in all that poetry and philosophy which tells of hope that still may live or of deeds that maybe done, "while the lamp holds out to burn."

Thus far, in spite of occasional glimpses of the Middle Ages and of modern times, we have dealt, for the most part, with earlier ages. Now our story must leave these behind, and thus passes the ancient world with its strange pagan civilization which was so human, so wise and so simple. It is difficult for modern Americans even to imagine existence in ancient Greece or Rome or in still more ancient Egypt and Mesopotamia – since the whole attitude toward life was so essentially different from what it is to-day.

Our debt to the ancients in this one matter of recording time is typical of that in many others. To them we owe our whole fundamental system and conception of it from the astronomy by which we measure our years and our seasons and make our appeal to the final standard of the stars, down to the arithmetic of our minutes and seconds and the very names of our months and days.

In the modern application and practical use of all this, on the other hand, we owe them nothing. They never made a clock or watch, or any like device which has more than a merely ornamental use to-day. They gave us the general plan so well that we have never bettered it, but they left later generations to work out the details. They invented the second as a division of time but they did not measure by it. They did not care to try. For them, learning was the natural right and power of the few, and the gulf between the most that was known by the few and the little that was known in general, was like the gulf between great wealth and great poverty among ourselves.

Indeed, in this age of teaching and preaching, when a thought seems to need only to be born in order to be spread abroad over the world, it is hard for us even to conceive the instinct by which men kept their learning like a secret among the initiated and felt no impulse to make known that which they knew.

Their great men thought and did wonderful things which are now the common property of us all. And their common folk lived in a fashion astonishingly primitive by comparison, in an ignorance which certainly was weakness and may somehow have been bliss.

That world of theirs is gone – the body and the spirit of it alike. And there remains to us, along with much of their art and their science, the hour-glass to symbolize that relentless flight of time which they feared but never tried to save; and the quaint sun-dial in our gardens, a memory of that worldly-wise old philosophy which counted only the shining hours.

CHAPTER SIX
The Clocks Which Named Themselves

Now the scene changes again, and the story shifts forward over the interval of a thousand years. As we take up the tale once more, we find ourselves in another world, amid a life as different from that ancient life of which we have been speaking as either of them is from our own life to-day.

The ancient civilization, which may be traced from Rome through Greece, Babylon and Egypt back to the dim dawn of history, is gone almost as if it had never been. For there came a period when great hordes of barbarians defeated the armies, burnt the cities, pillaged and destroyed, leaving only desolation and ruin behind them. Then followed hundreds of years of what we call the "Dark Ages," – ages of ignorance and violence, when mankind was slowly struggling upwards again and was forming a new civilization upon the ruins of the old. Therefore, at the point we have now reached, there are no more white temples and pillared porticos and sandaled men in white tunic and toga, and marble statues in green gardens; but everywhere we find sharp roofs and towers, quaint outlines, and wild color like a child's picture-book.

There are castles with their moats and battlements, and monasteries with their cloistered arches; there are knights in armor riding, and lords and ladies gorgeous in strange garments, and monks in their dull gowns, and the sturdy peasant working in the field; and in the towns, all among peaked gables and Gothic windows and rough cobbled streets, a motley crowd of beggar and burgher and courtier, priest and clerk, doctor and scholar and soldier and merchant and tradesman – an endless variety of types, and each in the distinctive costume of his calling. And there are churches everywhere, from the huge cathedral towering like a forest of carven stone to the humble village chapel or wayside shrine, their spires all pointing up to heaven in token of the change that has come upon the life and spirit of the world.

We have come from the height of the classic period suddenly into the heart of the Middle Ages; and in the dark centuries that lie between, Christ and His Disciples have come and gone, and the religion of the Western World has changed; the old gods have perished and the saints have filled their places. And Rome has died, and Romance has been born.

The center of civilization has shifted to the north and west; from the old ring of lands around the Mediterranean to the great nations of modern Europe. Italy has become a jealous group of independent cities, great in art and commerce, but in little else. Germany is much the same, except for the lack of some few score centuries of tradition. France and Spain are already great and growing. William the Conqueror has fought and ruled and died, and the "Merry England" of song and story has grown up out of the fusion of Saxon and Norman. Chivalry and the Crusades, the times of *Ivanhoe* and *The Talisman*, are as fresh as yesterday.

And by green hedgerows and hospitable inns, Chaucer's Pilgrims are plodding onward toward the sound of Canterbury's bells. For here is the point of all our seeking – that there are clocks now in the monasteries and in the Cathedral towers. There is just one curious link of likeness between the Middle Ages and the remoter past; as it was at first at Babylon, so now in the fourteenth century the priesthood holds almost a monopoly of science and of learning.

Thus, although the sun-dial, clepsydra and sand-glass are still much used, we find ourselves at last in the time and lands of *clocks*. The very sound of the word "clock" gives a clue to its origin. It suggests the striking of the hour upon some bell. The French called the word *cloche* and the Saxons *clugga*, and both of these originally meant a bell.

If you will put yourself back in the picture at the beginning of the chapter, you will find yourself in a realm of sounding, pealing, chiming bells with the hours of prayer throughout the day, from matins to angelus, rung out from the belfries, and with frequent deep-toned strikings of the hour. Not even a blind man could have remained unconscious of the passage of the hours under such conditions, and time, in a sense, became more a possession of democracy although timepieces themselves were still the mark of special privilege.

Life also was beginning to hurry just a little. Very deliberate, we should call it in comparison with the mad rush of the twentieth century, and yet it began to show its growing complexity in that humanity was becoming more definitely organized and men were forced to depend more and more upon each other. In all of this, there was a slightly growing sense of the things that were to be, just as the water for some miles above Niagara begins to hasten its course under the influence of the mighty cataract over which it will at last go madly plunging.

Herein occurs another of those baffling questions, like the old-time puzzler as to whether the hen first came from the egg or the egg from the hen. One cannot help wondering to what extent the increasing accuracy of the broadening knowledge of time-keeping was the *result* of our complicated modern life and to what extent it was the *cause*. Certainly we cannot conceive of present-day affairs as being conducted save in the light of moving hands and figures upon a dial.

From the Middle Ages, then, we get our word for clock and, which is more important, we begin to get some crude application of its modern mechanical principles. They were wonderfully skilful, those medieval workmen, considering the means at their disposal, and the ingenuity of some of their clocks is still a delight, but, perhaps, for better understanding of the story, we should stop for a minute to inquire exactly what a clock means from the mechanical point of view.

A clock is a machine for keeping time. And for this there are four essentials, without any one of which there would be no clock. First, there must be a motive power to make it run; second, there must be a means of transmitting this power; third, there must be a regulating device to make the mechanism move steadily and slowly, and keep the motive power from running down too quickly; and, fourth, there must be some device to mark the time and make it known.

In a typical modern clock the power comes from the pull of a weight or the pressure of a spring – although clocks may, of course, be operated by electricity or compressed air or some other means; also, the regulator is what is known as the "escapement" and the recording device consists of the hands, the dial, and the striking mechanism. Having stated this, let us return to the past and see if we can determine how these principles came to be applied.

This is not altogether easy. Our forefathers were less particular than we over such trifling questions as names and spelling – even the learned Shakespeare, long afterward, used several different spellings of his own name. Thus, when we see in the records of the period the name of "clock" or "horologe" we cannot tell with certainty what type is meant, since "horologe" meant simply a device for keeping time; it might have been applied equally well to a clock, clepsydra, an hour-glass, or even a sun-dial.

"It is quite possible," writes M. Gubelin Breitschmidt, the younger, an eminent horologist of Lucerne, Switzerland, "that a large number of the technical inventions of antiquity were lost during the migrations of the barbarians and under the chaotic conditions prevailing during the first thousand years of Christianity, but the most perfect surviving instrument for measuring time was the water-clock, known as the clepsydra, which was able to maintain its supremacy long after the appearance of the wholly mechanical clock, just as the beautiful manuscripts of the artist monks and laymen were favored by the cultured classes long after the invention of movable types for printing.

"The spread of Christianity throughout Europe caused the foundation of many religious communities, and the severe rules by which they were governed – fixing the hours of prayer, labor, and refreshment – forced their members to seek instruments by which to measure time. In the year 605, a bull of Pope Sabinianus decreed that all bells be rung seven times in the twenty-four hours, at fixed moments and regularly, and these fixed times became known as the seven canonical hours. The sound of the bells penetrated and came to regulate not only the life of the religious bodies but also that of the secular people who lived outside the walls of the monasteries. Oil-lamps, candles, hour-glasses, prayers and – for those who had the means of buying them – clepsydræ served as chronometers for the brotherhoods; so that one can easily imagine that many a monk sought to improve these instruments. But as yet, no one had found means to regulate the wheel-system of a movement. In the best instruments of this period, water supplied the motive power and served as well to regulate the action."

There is a general belief that Gerbert, the monk, who was the most accomplished scholar of his age, and who later became Pope Sylvester II, was the one who first took the important step of producing a real clock, and that this occurred near the close of the tenth century – or to be more exact, about 990 A. D. This period was one of densest superstition, and expectancy of the end of the world was in the air, since many people had fixed upon the year 1000 A. D. as the date of that cataclysmic event.

Authorities of the Church and of the state were not very partial to invention and research, their attention being fixed largely upon theological, political, or military affairs; but, of course, inquiring and constructive minds were still to be found; even without encouragement these tended to follow the impulse of their natures.

It is to the monks in their cloisters that we chiefly owe the preservation of learning through the "dark ages," and from the monks, for the most part, came such progress of science and invention as was made. If Gerbert, the monk, after patient tinkering with wheels and weights in his stone-walled workshop, really achieved some form of the clock-action as we know it, he was one of the great benefactors of the human race. Still, it is not impossible that his device may only have been a more remarkable application of the clepsydra principle.

Whatever it was, it seems to have startled the authorities, for they are said to have accused him of having practiced sorcery through league with the devil, and to have banished him for a time from France. His age appears to have had a vast respect for the intellectual powers of his Satanic Majesty. Anything which was too ingenious or scientific to be understood without an uncomfortable degree of mental application was very apt to be ascribed to diabolic inspiration and thus found unfit for use in "Christian" lands. It could hardly have been a stimulating atmosphere for would-be inventors.

All of the credit that we are ascribing to Gerbert must therefore be prefixed with an "if." Did he really invent the clock-movements, or is this merely another of the tales which have blown down to us from this age of tradition and romance? For similar tales are told of Pacificus in 849 A. D. of the early Pope Sabinianus in 612 and even of Boetheus, the philosopher, as far back as 510 A. D., while always in the background are claims of priority for the Chinese who are supposed to have discovered many of our most important mechanical and scientific principles away off upon the other side of the world before these were dreamed of in the west.

If all of these various claims were true, which is far from likely, it still would not need to surprise us, for it must be remembered that humanity, until within the past few generations, was more or less a collection of separated units and its records were very incomplete. There was scant interest in abstract research and very limited intercourse between towns and countries; one who made an important discovery in one locality might be unheard of a hundred miles away. Unless all the conditions were favorable, his ideas might even pass from memory with his death, until some scholar of modern times might chance upon their record.

All that can with certainty be said, therefore, is that there were clocks of some sort in the monasteries during the eleventh century; that back of these were the clepsydræ and other time recording devices; and that here and there through the preceding centuries are more or less believable tales of inventions that had to do with the subject.

Let it be remembered, too, that some of the brilliant minds of ancient times made discoveries that were forgotten after the barbarian waves overwhelmed preceding civilizations. The ages following the downfall of Rome were those of intellectual darkness, illiteracy, and rude force until mankind groped slowly back toward the light through the process of *rediscovery*.

Thus, it mattered not at all to the medieval world that Archimedes, the great Greek scientist and engineer – who, however, chanced to live in the Greek colony of Sicily – was able, somewhere about 200 B. C., to construct a system of revolving spheres which reproduced the motion of the heavenly bodies. Such a machine must necessarily have involved some sort of clock-work. We dare not stop to consider Archimedes, lest we stray too far from our subject, but this marvelous man of ancient times, the Benjamin Franklin of his day, seems to have had a hand in almost every sort of mechanical and scientific research, from discovering the principle of specific gravity, in order to checkmate a dishonest goldsmith, to destroying Roman war-ships by means of his scientific "engines." The story is told that he set the ships on fire by concentrating upon them the rays of the sun from a number of concave mirrors. And, although this story may not be true, the things that he is known to have done are extraordinary.

Archimedes and his knowledge had long passed away when the monastery clocks of the eleventh century began to sound the hour. These were the fruit of a crude new civilization just struggling for expression, and represented the general period when William the Conqueror led his Norman army into England.

CHAPTER SEVEN
The Modern Clock and Its Creators

We learn that toward the close of the thirteenth century a clock was set up in St. Paul's Cathedral in London (1286); one in Westminster, by 1288; and one in Canterbury Cathedral, by 1292. The Westminster clock and the chime of bells were put up from funds raised by a fine imposed on a chief justice who had offended the government. The clock bore as an inscription the words of Virgil: "*Discite justitiam moniti*," "Learn justice from my advice," and the bells were gambled away by Henry VIII! In the same century, Dante, whose wonderful poem the *Commedia*, (the *Inferno*, *Purgatory* and *Paradise*) is sometimes called the "Swan Song of the Middle Ages," since it marks the passing of the medieval times, spoke of "wheels that wound their circle in an orloge."

Chaucer speaks of a cock crowing as regularly "as a *clock* in an abbey orloge." And this shows, curiously, the early meaning of the word, for by the word "clock," Chaucer evidently meant the *bell* which struck the hour, and, very obviously, he used the word "orloge" to indicate the clock itself.

Many of these "clocks" had neither dials nor hands. They told time only by striking the hour. Sometimes in the great tower clocks there were placed automatic figures representing men in armor or even mere grotesque figures which, at the right moment, beat upon the bell. These figures were called "jacks o' the clock" or "jacquemarts" and curious specimens of them are still in existence.

The early abbey clocks did not even strike the hour but rang an alarm to awaken the monks for prayers. Here again, the alarm principle precedes the visible measurement of time; even now, as already noted, we speak of a "clock" by the old word for "bell."

In the course of the following century – the fourteenth – clocks began to appear which were really worthy of the name, and of these we have authentic details. They were to be found in many lands. One of them was built, in 1344, by Giacomo Dondi at Padua, Italy. Another was constructed in England, in 1340, by Peter Lightfoot, a monk of Glastonbury. And in 1364, Henry de Wieck, De Wyck, or de Vick, of Wurtemburg, was sent for by Charles V, King of France, to come to Paris and build a clock for the tower of the royal palace, which is now the Palais de Justice. It was finished and set up in February 1379, and there it still remains after lapse of five and a half centuries, although its present architectural surroundings were not finished until a much later date.

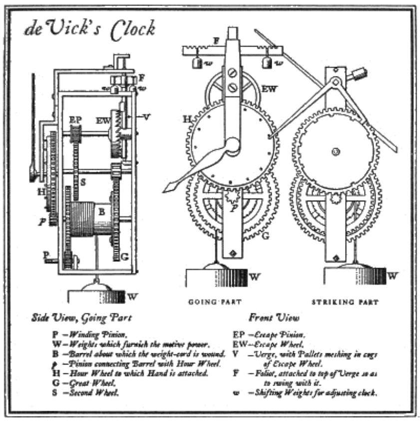
This venerable timepiece termed by some chroniclers "the parent of modern timekeepers," was still performing its duty as late as 1850. And so it is a matter of interesting record that its mechanism, which served to measure the passage of time in the days when the earth was generally believed to be flat and when the Eastern Division of the Roman Empire was still ruled from Byzantium, now Constantinople, has served the same purpose within the possible memory of men now living. Its bell has one grim association – it gave the signal for that frightful piece of Medicean treachery, the Massacre of St. Bartholomew, planned by Catherine de Medici, the mother of the King Charles IX, when the armed retainers of the crown of France flung themselves upon the unsuspecting Huguenots and caused the streets to run red with the blood of men, women and children – a ghastly butchery of thousands of people.

As we have seen, de Vick's clock was neither the earliest made, nor among the earliest; nor, probably, did it embody any at that time new mechanical invention. It does, however, fairly and clearly typify the oldest style of clock of which we to-day have any accurate knowledge. Compare its description, then, with the clock upon your shelf.

We think of the tall-cased "grandfather's clocks" as antique; but this tower-clock of de Vick's outdoes them in antiquity by some four hundred years. And its most interesting feature is its curious likeness in mechanical principle to the clocks of modern times. Like most early clocks, it has only one hand – the hour-hand. Its ponderous movement is of iron, laboriously hand-wrought; the teeth of its wheels and pinions were cut out one by one. It was driven by a weight of five hundred pounds, the cord of which was wound round a drum, or barrel. This barrel carried, at one end, a pinion, meshing with the hour-wheel, which drove the hands; the flange at the other end of the barrel formed the great wheel, or first wheel of the train. This meshed with a pinion on the shaft of the second wheel, and this in turn with a lantern-pinion upon the shaft of the escape-wheel. All of this is, of course, essentially the modern train of gears, only with fewer wheels.

The escapement is the most important part of the whole mechanism, because it is the part which makes the clock keep time. It is an *interrupter*, checking the movement almost as soon as, under the urge of the mainspring, it starts forward. The frequency and duration of these interruptions determines the rate of running. Without this, the movement would run down swiftly; with it, the operation stretches over thirty hours, involving 432,000 *interruptions*.

De Vick's escapement is shown in the illustration. The escape-wheel was bent into the shape of a shallow pan, so that its toothed edge was at a right angle to the flat part of the wheel. Near it was placed a verge, or rotating shaft, so called from a Latin word meaning "turning around." On this verge were fastened two flat projections called *pallets*, diverging from each other at about an angle of one hundred degrees. The width between the pallets, from center to center of each, was equal to the diameter of the wheel, so that one would mesh with the teeth at the top of the escape-wheel and the other with the teeth at the bottom.



de Vick's Clock

Now, if the upper pallet were between the teeth at the top of the wheel, the pressure of the wheel trying to turn would push it away until the teeth were set free. But, in so doing, it would cause the verge to turn and bring the lower pallet between the teeth at the bottom of the wheel. And since the bottom of the wheel was, of course, traveling in the opposite direction from the top, the action would be reversed, and the lower pallet would be pushed away, bringing the upper one back between the teeth of the wheel again; and so on, "tick-tock," the wheel moving a little way each time, and the pallets alternately catching and holding it from going too far.

The device was kept running slowly by means of a cross-bar called a "foliot," fastened across the top of the verge in the shape of a T, and having weights on its two ends. When this weighted bar was set turning in one direction, it would, of course, resist being suddenly stopped and started turning the other way, as it was constantly made to do. And this furnished the regulating action which retarded the motion of the works and kept them from running down.

This involves the principle of the modern balance-wheel in both watches and clocks, which is that of *inertia*; the rim of the balance-wheel represents the weights on the bar that resist the pull of the pallets. A vital improvement, however, is the interception of the hair spring which gives elasticity to the pull and thus supplies the elements of precision and refinement. The inertia of the balance-wheel is gauged by the weight of the rim and its distance from the center; and the last refinement of regulation of the mechanism is produced by moving the tiny screws on the periphery of this wheel outward or inward.

We shall see later how this old escapement was in principle much like the improved forms in use to-day. It was as quaint and clumsy an affair as the first automobile or the first steam-engine. But, like them, it was a great invention, destined to achieve great results. For it was the means of *making a machine keep time*. And every clock and watch in use to-day depends for its usefulness upon a similar device. The tick is the first thing we think of in connection with a clock; and it is the most essential thing also, *because it is the escapement which does the ticking*.

This old clock of de Vick's also struck the hours upon a bell and in very much the same way as modern clocks are made to do. But the mechanical means by which it did so are too complicated to be easily described here. And indeed it is unnecessary to do so, since the bell is far less important. A clock need not strike, but it must keep time.

On the fearsome eve of St. Bartholomew, therefore, and *again within the past generation*, the clanging of this old clock's bell was brought about by the whirling gears and ponderous weights of an early craftsman who wrought his work into the ages.

As already stated, de Vick's mechanism embodied mechanical principles which, although greatly developed and improved, are employed even at the present day. All the essentials of a clock are there; the motive power – the descent of a massive weight – is now replaced by a slender spring; the train of gears by which this motion is reduced and communicated, are cut to-day with the extreme accuracy of modern machine work; the hand moving around the dial is now accompanied by a longer, swifter hand to tell the minutes; the escapement which by checking the motive power while yet allowing it to move on step by step, retards and regulates – even the numbered striking of the unchanging hours.

De Vick's old clock may have been a crude machine – it certainly was a poor timekeeper – but it was the sturdy ancestor of all those myriad tribes of clocks and watches which warn us solemnly from our towers, chime to us from our mantels, or, nestling snugly in our pockets, or clinging to our wrists, help us to maintain our efficiency in the complexities of modern life. The mechanism employed by de Vick was retained without any improvement of importance in all the time-pieces of the next three hundred years. The foliot escapement, especially, remained in use much longer. Indeed, any modern watchmaker would recognize that it was practically a horizontal balance-wheel.

Long before it was improved upon, watches had been invented and clocks had everywhere become common. But we shall reserve the watch for the next chapter; for the moment, our concern is with clocks alone.

The disadvantage of the medieval clock was its inaccuracy. This was due first to crude workmanship and unnecessary friction; but that trouble was presently overcome, for the medieval mechanic could be as fine and accurate a workman as any modern. He had the artist's personal pride and pleasure in his skill, and also a great unhurried patience, somewhat hard for us to picture in this breathless age. At best, however, his work fell far short of the accuracy possible with modern machinery. Other important difficulties were found in the expansion and contraction of parts due to temperature variations, and the fact that the foliot balance was at its best only when running slowly. Altogether, then, these early clocks were easily surpassed in accuracy of timekeeping by a sun-dial or a good clepsydra.

The question arises, therefore, why this newcomer in the field of timekeeping, should have begun to displace the earlier devices. The clock was not yet a better timepiece than the sun-dial; why did it grow more common? Well, for one thing, people like novelties. For another, people loved their churches and lived by the chimes of distant bells; and the clock was by far the most practical striking device, whatever might be its faults in keeping time. But, what was most important of all, it was a machine, susceptible of infinite improvement and offering a field for endless ingenuity. It appealed to that inborn mechanical instinct by means of which mankind has wrought his mastery over the world.

We have seen how de Vick's clock contained, as it were, the germ of all our clocks. And, moreover, the medieval regarded machinery with profoundest awe. It is the unknown which awakes imagination. *We* wonder at the cathedrals of his day, but the medieval knew about cathedrals; he built them. Considering their comparatively cruder tools, lack of modern hoisting machinery, and so forth, their architectural and building abilities exceeded even those of to-day. On the other hand, a locomotive or a modern watch, such as we glance at without special notice, would have appeared to him the product of sheer sorcery, too wonderful to be the work of human hands.

The Middle Ages could not much improve their clock without some radical invention; and such a mechanical type of invention was yet the province of but few minds. The typical craftsman could merely make the clock more convenient, more decorative, and more wonderful. To this work, he and his fellows addressed themselves with all of their patient skill and their endless ingenuity for ornamentation.

They made clocks for their churches and public buildings, and elaborated them with intricate mechanical devices. The old "Jacks" that struck the bells were only a beginning. They made clocks for their kings and wealthy nobles, adorning them with all the richness that an artist could design and a skilful jeweler execute. They made clocks even for ordinary domestic use so quaint in design and so clever in workmanship that we exhibit them to-day in our museums. One difficulty in determining the date of the first invention is that long before the days of de Vick and Lightfoot, machines were made to show the day of the week and month and to imitate the movements of the stars; and the first horological records may refer to clock-works of this kind.

The famous clock of Strassburg Cathedral shows the extreme to which the medieval craftsman carried this kind of ingenuity. It was originally put up in 1352 and has been twice rebuilt, each time with greater elaboration. It is three stories high and stands against the wall somewhat in the shape of a great altar with three towers. Among its movements are a celestial globe showing the positions of the sun, moon, and stars, a perpetual calendar, a device for predicting eclipses and a procession of figures representing the pagan gods from whom the days of the week are named. There are devices for showing the age and phases of the moon and other astronomical events. The hours are struck by a succession of automatic figures, and at the stroke of noon a cock, perched upon one of the towers, flaps his wings, ruffles his neck, and crows three times. This clock still remains, having last been rebuilt in the four years 1838 to 1842. But its chief interest is that of a mechanical curiosity. It keeps no better time than a common alarm-clock, nor ever did. And in beauty as well as usefulness, it has been surpassed many times by later and simpler structures.

For the first really important improvement in clock making we must pass to the latter end of the sixteenth century. The Italian Renaissance with its great impulse to art and science has come and gone, and the march of events has brought us well into the modern world. America had been discovered a century and is beginning to be colonized. Spain is trying to found a world empire upon blood and gold and the tortures of the Inquisition. England is at the height of the great Elizabethan period. It is the time of Drake and Shakespeare and Sir Walter Raleigh.

At this period of intellectual awakening, a remarkable young man steps upon the scene. In 1564, the year in which the wonderful Englishman, Shakespeare, first saw the light of day, the scarcely less wonderful Italian, Galileo, was born in Pisa. He was gifted with keen eyes and a swift, logical mind, which left its impress upon so many subjects of human thought and speculation that we are tempted to stop as with Archimedes and trace his history. But, one single incident must suffice.

In 1581, this youth of seventeen stood in the cathedral of Pisa. Close at hand, a lamp suspended by a long chain swung lazily in the air currents. There was nothing unusual in such a sight. Millions of other eyes had seen other suspended objects going through exactly this motion and had not given the sight a second thought. At this moment, however, a great discovery of far-reaching application – one which was to revolutionize clock construction – hung waiting in the air. Young Galileo took notice.

The lamp swung to and fro, to and fro. Sometimes it moved but slightly. Again, as a stronger breeze blew through the great drafty structure, it swung in a considerable arc, but always – and this was the point which impressed itself upon the Italian lad – the swing was accomplished in exactly the same time. When it moved a short distance, it moved slowly; the farther it moved, the faster became the motion; in its arc it moved more swiftly, accomplishing the long swing in the same time as it did the short one. In order to make sure of this fact, Galileo is said to have timed the swinging lamp by counting the beating of his pulse.

Thus was discovered the principle of the pendulum and its "isochronism." By "isochronism" we mean *inequal arcs in equal time*. In other words, any swinging body, such as a pendulum, is said to be "isochronous" when it describes long or short arcs in equal lengths of time. This also applies to a balance-wheel, and hair-spring. And herein lies a remarkable fact – this epoch-making discovery was after all but a rediscovery. The isochronism of a swinging body was known in Babylon thousands of years before, although the Babylonians, of course, could not explain it. Lacking in application, it had passed from the minds of men, and it remained for Galileo to observe the long-forgotten fact and to work out its mechanical application. He did not himself apply this principle to clock-making, although some fifty years later, toward the end of his life, he did suggest such an application.

The first pendulum clocks were probably made about 1665, by Christian Huyghens, the celebrated Dutch astronomer and mathematician who discovered the rings of Saturn; and by the English inventor, Doctor Robert Hooke. The invention is claimed for several other men in England and abroad at about the same time; but hardly upon sufficient authority.

From that time on, the important improvements of clockwork were chiefly made in two directions – those of the mechanical perfection of the escapement and the compensation for changes of temperature.

There is a little world of invention and discovery behind the face of the clock which beats so steadily on your mantel. Look within if you will, and see the compact mechanism with its toothed gears, its coiled spring, or its swinging pendulum, in which the motion of the cathedral lamp is harnessed for your service, – nothing in that grouping has merely happened so. You may or may not understand all the action of its parts, or the technical names of them; but each feature in the structure has been the result of study and experiment, as when Huyghens hung the pendulum from a separate point and connected it with a forked crank astride the pendulum shaft. You can see that forked crank to this day, if you care to look; it was the product of good Dutch brains.

Next we come to one of the greatest single improvements in clock-work, and the chief difference between the mechanism made by de Vick and the better ones of our own time. When the pallets in a clock are forced by an increased swing of the pendulum or by the form of the pallet faces against the teeth of the escape-wheel in the direction opposite to that in which the wheel is moving, the wheel must be pushed backward a little way each time, and the whole clock action is made to back up a little. You can see that this would tend to interfere with good and regular timekeeping. George Graham, in London, in 1690 corrected this error by inventing the *dead-beat escapement* which rather contradicted its name by working very well and faithfully.

There are many forms of this escapement and there is no need to explain it in detail. But the main idea is this: At the end of each vibration or swing of the pendulum, the escape-teeth, instead of being made to recoil by the downward motion of the pallets, simply remains stationary or at rest until the commencement of the return swing of the pendulum. This was brought about by applying certain curves to the acting faces of the pallets. But the acting faces of both tooth and pallet are beveled, so that the tooth in slipping by gives the pallet a "kick" or impulse outward and keeps it in motion. Nowadays, even a common alarm-clock has an escapement working in this way.

Then came another remarkably interesting contribution. Have you ever wondered why the pendulums of fine clocks were weighted with a *gridiron* of alternate rods of brass and steel? For purpose of ornament? Not at all – it constitutes a scientific solution of an embarrasing problem, due to the inevitable variations in temperature. Metals expand with heat and contract with cold. Notched iron bars can be made to "crawl" along a flat surface by alternately heating and cooling them. Bridge-builders sometimes arrange sliding points, or rocking points to adjust the differences in the length of the steel. Contraction and expansion are important factors in all their calculations. But a pendulum would change its rate of motion if it changed its length and this would interfere with its accuracy as a measurer of time. Graham worked upon this problem, too, and attached a jar of mercury to the rod of his pendulum for a weight. When the heat lengthened the rod, it also caused the mercury to rise, just as in a thermometer, and this left the "working-length" the same.

Such mercury-weighted pendulums are not uncommon to this day, but the more familiar *gridiron* came from the brain of John Harrison, who, in 1726, fixed the alternate rods in such a way that the expanding brass rods raised the weight as much as the expanding steel rods lowered it. Thus they neutralized each other.

The clock as we know it was now virtually complete. There were structural refinements, but no more radical improvements to be made. In tracing its development from the fourteenth to the eighteenth century, we note one curious likeness to the ancient history of recorded time. In this case, as before in Babylon, the people first concerned with the science were the priests, and after them the astronomers, but we note a still more important difference.

As the medieval passed into the modern, the practise of horology passed more and more out of the hands of scientists into the keeping of commercial workmen. The custodian of time was at first a priest, and finally a manufacturer. And this change was attended by a vast increase in the general use of timepieces, and the correspondingly greater influence of time upon society and men's way of living. The Middle Ages made clocks and watches; and clocks and watches make the age in which we live.

CHAPTER EIGHT
The Watch that Was Hatched from the "Nuremburg Egg"

In the second act of Shakespeare's play, *As You Like It*, when Touchstone, the fool, meets Jaques, the sage, he draws forth a sun-dial from his pocket and begins to moralize upon Time.

Touchstone's dial must have looked like a napkin-ring, with a stem like that of a watch, by which to hold it up edgewise toward the sun, and a tiny hole in the upper part of the ring through which a little sunbeam could fall upon the inner surface whereon the hours were marked. This pinhole was perhaps pierced through a slide, which could be adjusted up or down according to the sun's position at the time of year. In principle, therefore, it was a miniature of the huge dial of Ahaz of more than two thousand years before.

In another Shakespeare play, *Twelfth Night*, Malvolio is gloating in imagination over his coming luxury when he shall have married the heiress and entered upon a life of wealth and leisure.

"I frown the while," says he; "and perchance wind up my watch, or play with my – some rich jewel."

There, in those two quotations, we have the whole meaning of the watch in the time of Queen Elizabeth. Touchstone's dial was a practical convenience – a thing to tell the time. Malvolio's watch was a piece of jewelry, an ornament indicating wealth and splendor. While watches had been well known for many years, people wore them chiefly for display and told time by means of pocket sun-dials.

For the first watches we must go back to about the year 1500, shortly after America had been discovered, and when the great tower-clocks of de Vick and Lightfoot were not much more than a century old. In the quaint old town of Nuremberg there lived, at that time, one Peter Henlein, probably a locksmith. But a locksmith, in those days, would be an expert mechanic – more like a modern toolmaker; very likely an armorer also; capable of that fine workmanship in metal which we still wonder at in our museums. Nuremberg was then very much a medieval city, all red-tiled roofs and queer windows, where people went about dressed in trunks and jerkins and pointed caps and pointed shoes. It looked like *Die Meistersinger*, and *Grimm's Fairy Tales*, and pictures by Howard Pyle and Maxfield Parrish; very much like "Spotless Town," except that it was far from spotless.

Now, as you remember, there was not until long after this any means of making clocks keep anything like accurate time; so, instead of improving them, people competed with each other in devising novel and ingenious forms. There could be no more desirable novelty than a clock small enough to stand upon a desk or table, or even to be carried around. Such a clock could not well be driven by weights. But Peter Henlein overcame that difficulty by using for the motive power a coiled mainspring wound up with a ratchet, just as we still do to-day.

There is some dispute over attributing to Henlein the credit for this invention; but at least he did the thing, and it cannot be proved that anybody did it before him. "Every day," wrote Johannes Coeuleus, in 1511, "produces more ingenious inventions. A clever and comparatively young man – Peter Henlein – creates works that are the admiration of leading mathematicians, for, out of a little iron he constructs clocks with numerous wheels, which, without any impulse and in any position, indicate time for forty hours and strike, and which can be carried in the purse as well as in the pocket."

There was, however, no invention of any such thing as we mean by the term *watch* to-day that came complete from the mind of any one man, but the contrivance gradually grew, in shape and structure out of the small clock which could be worn at the belt or on a chain round the neck. It came to be called a *watch* because *clock* meant a bell that struck the hours. But many of the first watches had striking apparatus, and this circumstance added to the confusion of names. We slangily call a fat, old-fashioned watch a *turnip*; but the first watches were very much fatter and more old-fashioned, and might fairly have deserved the name. Before long, Henlein was making them oval in shape. Hence, they were called *Nuremberg eggs*.

Here, then, is something which we can really consider a watch. Let us see how it compares with those that we know to-day. In the first place, being egg-shaped, it was thick and heavy – you would not like to carry it in your pocket. It had no crystal and only one hand – the hour-hand. So much for the outside.

Inside, the difference was still greater. The works were made of iron and put together with pins and rivets. It was all hand-work – expert workmanship, indeed – but look at the works of your own watch and try to imagine cutting the teeth in those tiny gears, or making those delicate springs with files and hammers. As pieces of hand-workmanship, therefore, the watches made by Henlein and his followers were remarkable; but when compared with our modern watches, they were crude and clumsy affairs.

Furthermore, they were poor timekeepers. They had the old foliot balance running parallel to the dial. This was all very well as long as the watch lay on the table with the balance swinging horizontally. But as soon as it was carried, in a perpendicular position, the arms of the balance had to swing up and down, which was quite another matter. And then, of course, the crudeness of the works produced a great deal of friction. This made it necessary to use a very stiff mainspring, otherwise the watch would not run at all. Such a spring exercised more pressure when fully wound than when it was nearly run down. And so the worst fault of the foliot was that it speeded up under increased pressure.

The first improvements, and, in fact, the only ones for nearly two hundred years, were directed toward doing away with the unequal pressure of the mainspring and thus make the watch keep better time. If you look into the back of a very early watch, you may see a curious device consisting of a curved arm ending in a pinion, which travels round an eccentric gear of peculiar shape. This is the first type of equalizing mechanism; it was invented in Peter Henlein's time and was called the *stackfreed*; but it was a clumsy device at best and a great waste of power. Therefore it was gradually displaced by the *fusee*.

Perhaps one might have felt a certain amount of pride in carrying about such a thick, bulging mechanical toy, as were these early watches, but, as to possessing something that would keep correct time – that was a different matter. After admiring it and listening to its ticking, one would have to guess as to just how far wrong it might be. People did not figure closely on minutes and half minutes in the day of the *Nuremberg egg*; there was no "Wall Street" and no commuting. And this brings us to a real event in the whole story.

Jacob Zech, a Swiss mechanic, living at Prague in Bohemia, Austria, about 1525, began studying the problem of the equalization of watch mechanism. He was sure that there ought to be some better means than that of the clumsy stackfreed. Presently he hit upon the principle of the fusee, and Gruet, another Swiss, perfected it. At last it became possible to make a watch that would not run fast when first wound and then go more and more slowly as it ran down – and to do this in a really practical way. Before this time, a watch was a clumsy piece of ticking jewelry; now it became something of a real time-keeper. Therefore, it was not long before people began to want Swiss watches. These were the days when skilful Swiss craftsmen worked patiently in their little home shops, making some single watch-part and making it extremely well, while the so-called "manufacturer" bought up these separate parts, and assembled them into watches.

What was the fusee that brought about such a change? Not much to look at, surely – merely a short cone with a spiral groove running about it, and a cord, or chain, wound in this groove and fastened at the large end of the core. Its principle and its action were very simple, and that is why it was a great invention. Some one has said that anyone can invent a complicated machine to do a piece of work, but it takes real brains to make a *simple*

Конец ознакомительного фрагмента.