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TIMEKEEPING THROUGH THE AGES.

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in answer to the numerous inquiries received  
from school children about clocks.

The National Bureau of Standards in Washington, D. C., receives hundreds of letters each year from children all over the country who are anxious to obtain information on many different subjects. One of the subjects which fires the imagination of these youngsters is that of timekeeping. What kind of clocks were used in the past? How will people be telling time when they become men and women? Will it be by some new mechanical device, or will it be by some strange method as yet wholly undreamed of?

This article is written specifically to aid school children in obtaining a clearer understanding of the different timepieces used in the world down through the ages.

At the National Bureau of Standards, experts test watches and clocks to see how accurately they keep time in different positions and at different temperatures.

They are compared with the Bureau's standard clock which keeps time to within two one-hundredths of a second a day. To almost anyone this would seem to be accurate enough, yet this clock must be checked regularly, through the radio signals from the Naval Observatory, with true time as obtained from the stars. The heavy steel pendulum swings back and forth in a partial vacuum and each swing is one second of time on the clock. The "rate" is regulated by the amount of air in the chamber in which the pendulum swings. If it swings too fast, a little air is let into the chamber, or if it is moving too slowly, a little air is taken out. The seconds ticks from the standard clock can be sent by wire to any laboratory in the Bureau where exact time service may be needed.

And now let us ask "Old Father Time" to retrace his footsteps back to the far off past when he was a much younger man!

The philosopher says that "what we call time is the duration measured for all things, with a beginning and an end between an eternity past and an eternity future." We have learned to divide time into certain lengths, which we call years, months, days, hours, minutes and seconds. The story of this careful development of the means of reckoning duration, or time, leads back thousands of years. Some early people reckoned it by the

sun, others by the moon. The American Indians kept an account of long periods by "winters", of months by "moons", and of days by "sleeps". When computed by the sun's day was from sunrise to sunset; this was divided into hours, but as the days were of unequal length the hour varied in the different seasons from forty-five minutes to seventy-five minutes. At length the hour-glass made it more convenient to divide the time from sunrise to sunrise into twenty-four equal parts. There was no agreement as to when the day began, however. Some people counted the day from sunrise, some from sunset, others from midnight and still others from noon. By general custom we now declare the day to be from midnight to midnight.

The oldest known device for measuring time is the sundial. The earliest mention of it was in the Bible, "Behold, I will bring again the shadow of the degrees, which is gone down in the sundial of Ahaz, ten degrees backward." The probable date of the sundial referred to is about 700 B. C. The earliest sundial of which there is certain knowledge is the dial of Berossus, a Chaldean astronomer who lived about 300 B. C. This dial was a hollow hemisphere, set with its rim horizontal and with a small bead fixed at the center. The shadow of the bead, during the sun's progress from east to west, de-

scribed a circular arc. This arc was divided into twelve equal parts. The dial, as a consequence, divided the day, from sunrise to sunset, into equal parts, which were called temporary hours. The length of these hours necessarily varied with the seasons. For sixteen hundred years sundials, though built in various ways, were all based on the principle of temporary hours. In Mohammedan countries these romantic timepieces are still used!

The sand-glass, unlike the ancient sundial in that it was a "bad weather" as well as a "fair-weather" recorder, was also used extensively in the early days.

From the very earliest time man naturally desired to have some means of recording the passage of time, and the modern clock, instead of being a single invention, is in reality the result of a more or less gradual growth of ideas. The Indians of North America prior to the coming of the white man measured time by moons, each moon measuring the time from one new moon to the next. The hours of the day were indicated by the height of the sun. Such methods, though primitive, were practical, as there was no need for great exactness - several minutes either way made no real difference.

The first mechanical device for keeping and indicating time was the clepsydra or water-clock which was in use in ancient Greece and Rome over 2000 years ago. The

simplest water-clock consisted of an earthen vessel with a small hole in the bottom. This device was filled with a certain amount of water and the liquid was allowed to trickle out of the hole. In approximately the same lengths of time this device would empty itself. A more elaborate water-clock consisted of a cylinder into which water dripped, and as the cylinder filled the water raised a float which was connected through simple gearing to a hand on a dial upon which the hours were indicated. We thus have the first application of wheels to a clock, this form being said to date from 245 B. C.

Notched candles were also used as early time-keepers. A candle always made of the same material, of the same size, and with a wick of the same material and size burns very nearly the same numbers of inches each hour. Notches or marks were placed on candles at such a distance apart that a certain number of spaces would burn each hour. They thus served in a rough way to keep the time and subdivide the day.

The invention of the clock with weights and wheel-work is attributed by some authorities to the Chinese at least 2000 years before the Christian Era. If such be the case, the art of clock-making was long lost, for it was not known to Western countries until many centuries later. Clocks are rumored to have been constructed in

Europe in the sixth century. By the fourteenth century at any rate, clocks were being produced in large numbers, particularly in Germany, and Germans have continued to be among the world's foremost clock-makers ever since.

The introduction of the pendulum as a means for governing clocks had a radical effect on clock design. By pendulum we mean a heavy body, not necessarily rigid nor even entirely solid, which swings to and fro freely by its own weight about some point of support. The principal advantage of the pendulum is its almost perfect isochronism, that is to say, it swings almost in the same time, though the arc through which it swings may vary. Undoubtedly, the man to whom is due the introduction into general notice of the pendulum as a clock governor was Christian Huygens van Zulichem, commonly called Huygens. He was a student of the University of Leyden, Holland, and was one of the foremost mathematicians and natural philosophers of his time. The pendulum was applied to clocks by him in 1656 although tradition ascribes this application to Galileo Galilei at a still earlier date.

For centuries weights were used for driving clocks, but eventually it was discovered that clocks could be made without them and that a steel spring would perform the same office, while instead of having a pendulum, a

balance wheel, "escapement", and hair-spring could be used to prevent the other wheels from turning too rapidly. Small clocks and watches are made on this principle, and both were impossible before the adoption of the spring; all that is necessary to start the mechanism is to wind, or tighten, the spring.

Our present clocks with dials and two hands developed only after clock work had been used for many years to strike a bell at regular intervals, but which furnished no information as to the time between. In fact, the work "clock" and its equivalent in various languages comes from the word for bell. In modern striking clocks a weight or spring sets in motion wheels which release a hammer at certain times. The hammer falls on a bell or rod of metal and announces the hour. Many clocks have elaborate devices for striking chimes on a series of bells, for playing tunes, and for making certain figures go through regulated motions at regular intervals.

One of the most important recent developments in timekeeping is the operation of a number of clocks by small electric motors which run at uniform speed. Nearly all electricity today is distributed by alternating current, and there is a certain type of electric motor called the "synchronous" motor which will keep in step with the generator at the power plant. Tiny motors of

this type are applied to driving clocks, and so long as the generator is regulated to run close to its assigned speed, all the little motors which receive current from this generator and keep in step with it will thus be running at a uniform rate. Now it is a curious fact that although electric power companies are not primarily concerned with driving clocks and thus telling people the correct time, they are vitally interested in closely regulating the speed of their generators so that different power plants can all be connected together, forming a power generating network. It is for this reason that every effort is made in a big electric generating station to keep the generators running at exactly the right speed. This is attained by checking them against a high-grade master clock in the power plant. Thus, this fine clock is, in effect, made to keep time for you in your own home.

Recently an 800-pound cupaloy "Time Capsule" was deposited 50 feet below the surface of the New York Worlds Fair grounds by the Westinghouse Electric and Manufacturing Company. We can't help wondering when this "Capsule" is opened in the year 6938 what the people will think of the little wrist watch which is one of various articles enclosed therein. Will they



look upon this little timepiece of the twentieth century as a crude oddity just as we today consider the ponderous works of the early clocks - made of heavy iron in a blacksmith shop? Time alone will tell!

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