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WHAT TIME IS IT?

Time and time-keeping involve everyone. Everyone is regulated by time. Trips are planned-- how many days are involved, arrival time and departure dates, How long will it take for a surgical operation, extract a tooth, set up a machine, turn threads on a rod, walk or drive to work, and you can think of as many others which arise in your vocation. There are those who have no use for a watch--those who almost abhor arriving at an appointed time-- the watch serves as no signal to them--the watch's face tends to have almost a mesmerizing effect. Fortunately, most people have a great deal of use for a watch. They, however, take the accuracy of their clocks and watches for granted. Yet it has taken over six thousand years to reach today's standards. For a long period religious sects were those most preoccupied with time-keeping. The monks of the Dark Ages chanted verses to mark the canonical (KA-NON'-I-KAL) hours. After mechanical time-keepers came on the scene--clocks about AD 1300, and watches around 1500 AD--they became status symbols of the time, like fast cars and yachts today.

The fact that 16th century watch and clockmakers were as valuable to their communities as 20th century atomic scientists to theirs has long been forgotten, as has the fact that clocks and watches were the first technical products to open up Europe's trade with the East. In the 18th and early 19th centuries, it was the mastery of time-keeping at sea, hence accurate navigation, that led to the domination of the British Navy, acquisition of the British Empire, and accurate charting of the world's coastlines.

Many essentials of modern life were first the brain-children of clock and watchmakers- the chaindrive, for example, the cardan shaft, differential gearing used in the back axles of motor cars, the thermostat in every oven, and the principle of feedback in automation. Todays space travel would be impossible without quartz clocks, and the atomic clock that is accurate to the equivalent of one second in three thousand years.

This discourse shall try to give with some detail the evolution of present time pieces, early calendars, and the development of accuracy of time pieces. This will not be an article on horology, which is the science of measuring time, or the art of constructing time-pieces. This paper will not assure one of having the correct time, or help one in keeping appointments, but hopefully will point out what is availabe to help those who need holp, or who wish to obtain an extremely fine time-piece.

Man's first clok was himself. Every living organism has a built-in "biological clock" that controls its habits. Many of man's psychological activities such as the times at which he feels hungry, are geared to a twenty-four rhythm. There are also lunar-daily, monthly, and yearly cycles. The behavior of plants and animals has been studied and related to cycles. The growth of a potato, for example, has a daily cycle related to the lunar month. Nature provides a number of natural clocks. The passage of the sun(or, as it was later discoverd, the rotation of the Earth) marks the interval known as a day. Repetition of the moon's phases marks a month. The recurring seasons indicate the lapse of a year. The week is a man-made invention. So is the hour. Why the day became divided into twelve hours is not known, but is is possibly associated with he magical significance of that number. There were twelve Great Gods of Olympus, twelve Labours of Hercules, Twelve Tables of Roman Law, and twelve Apostles of Jesus Christ.

The measurement of time by an instrument is one of man's earliest scientific achievements. The first time interval of which he became aware was undoubtly the day, marked by the rising the setting sun. Around 4000 BC, villages used the shadow of a tall palm tree as it moved across the ground to indicate the intervals of day-light. But palm trees die, and bend in the wind. At some period, a person in authority thought of replacing the palm tree by a tall stone or obelisk to indicate the hour by its shadow. One of the most famous of these was the obelisk of Luxor, in the ancient city of Thebes. It now stands in the centre of the Place de la Concorde in Paris. Rome has about twenty obelisks in various squares, carried there by early

Emporers, and in London, on the Thames Embankment is the famous Cleopatra's Needle, sister of a similar column near Cairo. This Needle was first erected at Hē-li-op-ō-lis Heliopolis, Egypt, about 1500 BC, moved to Alexander by order of Caesar Augustus in 23 BC, and brought to London at the beginning of the last century.

Days were divided into hours, but not the hours we use today. Early civilizations regarded days and nights as separate periods, and were divided each into the same number of "temporal hours", usually twelve. Only the astronomers lumped day and night together as one period, dividing it into twenty-four periods of equal lengths. These equal hours did not come into use in civil life until the 14th cnetury AD. The length of a temporal hour of the day was therefore, different from a temporal hour of the night, and both varied in length according to the season of the year except at the equinoxes, when they were equal. To start daylight hours from dawn introduced the difficulty of deciding exactly when dawn began. Some thousands of years later the Muslims decreed that it should start when it was possible to distinguish black threads from white ones in a tassel. About 4000BC the Egyptians employed twelve temporal hours and divided the month into three "decades" of ten days each, probably because they counted on their fingers.

We mentioned the shadow clocks, such as the obelisk, but there were also portable ones for business or domestic use. The portable one was t-shaped, and arranged so that a shadow of the crosspiece fell on the main stem, which was marked in hours. Another version of the shadow clock was the sun dial. One of the early ones was found in Egypitian excuvations and was in the form of a flight of steps on which the shadow of a wall fell. The first authentic reference known to a sun-dial-- in the Bible, 2nd book of Kings, Chap. 20-- is to one of this type which belonged to King Ahaz. On it, Isaiah the prophet performed the mircle of moving the shadaw backward by four degrees. This date was about 696 BC. Egyptian astronomers knew how to find the time at night by observing the passage of certain stars as they came into line with two plumb lines on successive nights, but this technique was too scientific for households, which used water clocks at night and in cloudy weather. A water clock operated by water dripping from a small hole near the bottom of a vessel, slowly filling another vessel. The walls of one of the two vessels were marked to indicate the hours.

Sand glasses came later than water clocks. They were constructed on the same principle, as the water-type, measuring the passage of time by sand running from a container into a lower one, which in turn was marked by a scale. We see them still in use as an egg timer. Ships of the Royal Navy had four-hour sand glasses to time watches until as late as 1839, and the Speaker of the House of Commons used a two-minute sand glass to time divisions until after the Second World War-- sometimes just for traditional purposes. The sand was often powdered egg-shell. It is recorded too that with the use of the water clock unscrupulous Roman lawyers whose speeches were timed by water clocks used to gain time by secretly dropping a little mud into the water to slow down the clock! Water clocks became more and more ingenious and complicated in the first centuries of the Christian era. Fire clocks were used almost as extensively as water clocks from about the 9th century AD in the Far East. The earliest was probably the match cord which burned like a fuse and was knotted at intervals to indicate hours. The most common form of fire clock was the joss-stick-clock,or incense clock. (The joss stick was a mixture of clay and sawdust from aromatic woods with some musk and gold dust pasted with water and glue on a long, thin sliver of bamboo.(It was marked at itervals representing the hours as it burned down). They might be found today in curio shops and are usually identified as opium stoves, hand warmers, or something else. CHINESE fire clocks were introduced into Japan between the 6th and 9th cneturies. A special type of joss stick was developed for geisha houses to calculate charges for entertainment. As a girl retired with a guest, a joss stick was lit and placed above her name, and a "flower girl" might earn several sticks during a day. Even now in Japan although, joss sticks are no longer seen, it is customary to ask "what is the price of a flower girl incense stick?"

Then came candles, and lamp clocks. The Saxons, the Teutonic race that conquered England by the 7th Century, used marked candles fortelling the time. Each candle woudd burn for four hours. In the lamp clock, the oil was contained in a resevoir and the amount of oil left showed the amount of time elapsed. Lamp clocks were in common use until the 19th century for telling the time at night.

There was another type of water clock known as sinking bowls. The bowl was placed on the surface of still water, with the bowl sinking in a given time.

When the compass was introduced into Europe in the 12th century, a compass sun-dial became popular. Arab astronomers discovered that if the Norman gnomon, or pointer, on a compass dial were placed parallel to the earth's axis, the sun-dial would read the same at any latitude. About 1520, astronomers noted that the star constellations moved around the Pole Star in 24 sidereal hours.

We have given some space to early means of recording time, and now we will make some observations of the early mechanical clock. It is surmised that the first mechanical clocks were small alarms that alerted the sexton of the church to his duty of ringing the big bell, and that they were replacements for less reliable devices such as water clocks, and time candles. The word "clock" seems to have come into use about 1330, when Richard of Willingford used it to deseribe his amazing mechanical astronomical clock in notes for the monks. It is likely that this monastic alarm merely struck a single tone on a bell and had no dial. Public clocks then began to appear, set in towers, so that the sound of the struck bell could be heard for some distance. These turret clocks were often struck by "jacks" or mechanical figures, that would strike with hammers held by horse figures, knights, or whatever the imagination might devise. Various escapements were developed to regulate the speed of the time piece, and they in turn were connected with gear wheels, and they with the crown wheel to turn the hands on the face of the clock. Time was shown by a single hour hand, or the dial turned against a stationary point. Gothic clocks struck the hours and sounded an alarm when required. For two centuries, all mechanical clocks had a weight drive like early water clocks. The first big impetus to the craft of clockmaking came with the invention of the coiled spring to replace the driving weight.

The clock spring revolutionsed clock making. It was responsible for the introduction of the portable clock, and the little clock that could be carried about the person-- that is, the watch. The first places to emerge as centres of clock and watchmaking were the towns of Augsburg and Nuremberg in S. Germany, probably because of the high number of skilled smith-gunmakers located in that area. The coiled spring replaced the weight and rope wound around a barrel which drove the clock with one end of the length of spring attached to an arbor, and coiled around it. The other end was attached to a fixed point on the movement, with the spring turning the arbor as it tried to uncoil. The spring driven clock was invented before the mid 15th century, but it was a long time before portable clocks came into general use, largely because of the difficulty in making springs. Because a spring will not give constant power like a weight acting under the influence of gravity, time keeping could still stand improving. As a spring runs down there is an uneven power output, with the result that many devices evolved to overcome this fault. There seems no end to the ingenuity of the clockmakers in Augsburg, coming forth with innumerous types of figures, animals, etc. Nuremburg appears to have concentrated more on watches. The most unusual domestic clock in England before 1600 was the imported iron Gothic clock. English clock makers then turned to the use of brass, or "latten" which later were called lantern clocks, as the shape was something like the horn lantern of the time. They were weight driven, and before 1657 when the pendulum clock was invented, all of them had balance wheels. If any lantern clocks survived they were later converted to the pendulum type for better timekeeping. At the end of the 16th century, Augsburg and Nuremberg were still dominant in clock and watch making. At this period in history, clockmaking enjoyed a very high standing, equivalent to electronic computer manufacture of today. It was the first industry to apply the theory of physics and mechanics to machines and many clock makers were scientists in their own right. Their products were sought after by the astronomers, the rich and the powerful, and were the basis of the most profitable trading with the East.

The first watches were made in Europe-- perhaps Burgundy or Flanders-- not long before 1500. The iron movements were set in bell-shaped cases, which were similar to the then popular so-called "musk balls"(containing musk, as scent is used today), also hollow metal spheres. A musk ball watch had a small dial at the bottom, and it was hung from the neck or kept in a purse. This was a novelty. Noremberg in S. Germany was perhaps the earliest production centre, although, Blois, in France, was also known for its watches at a very early date. Canister, or drum watches were made in some numbers in the 16th century, in Germany, and had iron movements. It had a hinged lid which could be raised to reveal the engraved dial with its hour hand. ~~There still was no glass available.~~ France began to take over the lead of watch making from GErmany, and in the 16th century, France introduced the oval shaped watch, which still had straight sides. Towards the end of the century, both round and oval watches began to appear with rounded sides. Geneva, Switzerland became a watchmaking centre some time after 1550, and London followed about 1600, both helped by HUGUENOTS escaping religious persecution. There was almsot complete internationalism in the watch trade from the beginning and little resistance to new ideas or foreign craftsmen. At a later stage, when the trades became established and trade guilds were formed, foreign workmen were not so welcome and there were rebellious outbursts against the "Strangers Artificers." From early days a watch was made by several craftsmen. A maker would produce some parts himself, buy others, assemble the movement to his own design, have a case made by a goldsmith, then engrave his hame and town on the watch. More crafts were involved with watchmaking then with clock making. Before 1650, the watchmaker was supported by a jeweller, a goldsmith, an engraver, an enameller, a lapidary case-maker, and perhaps others. The lapidary casemaker was a cutter and polisher of rock crystal. Glass over the dial had not yet been introduced, so at times, part or all of the case was made of the transparent natural quartz known as "rock crystal."

The biggest technical change in watches occured soon afrter 1675 when the balance spring, or hairspring, was introduced. This did much the same for the watch as the pendulum did for the clock, increasing its accuracy to an exceptional degree in a single jump. The pendulum has the forc e of gravity acting as a spring continuously pulling it into the zero position; the hairspring does the same for a watch, pulling the spring into the central position. The improved timekeeping with the balance and hairspring also meant the rapid introduction of another hand-- the minute hand. The two hands on a watch were still novel to most people in the 17th century, and it was not taught to children as a normal part of their upbringing.

In the 18th century, the English became the most dominating watchmaking nation, replacing the French, and Swiss. The main reason for this was the introduction of more efficient working methods. Thomas Tompion was one greatly responsible, and he came up with the idea that one person should make the wheels, one the spring, another engrave the dial-plate, and another the case, rather than the entire whole work be placed upon one man. The English also led in technical innovation, such as the jeweled bearings which reduced friction, and wear. Watches were generally wound by using a separate key until after mid-19th century. The wrist watch did not gain popularity until during the 1st World War, when it was discovered it was far easier to have the watch attached to the wrist rather than extract it from under a Sam Brown belt. The self-winding watch made its appearance in 1924, but the 1931 slump retarded the idea. In 1960, the turning fork was introduced, which replaced the balance wheel and drives the hands by a remarkable minature pawl and ratchet WHEEL. The latest, which will be discussed later, is the quartz=crystal electronic watch, brought out in 1967.

In the area of navigation, an accurate time piece is of extreme importance. In rather desperation, the British Governement in 1714, passed an Act of Parliament, which offered a top award of £-20,000 for practical methods of finding longtitude at sea. The navigator who ventured away from the coast had to be something of an astronomer, and mathematician to find his position-- North, or South, his latitude. He did this by taking an observation of the height of the sun in day time, or certain stars at night. To find his position of East or West, his longtitude, was almost impossible. So, the Capt. would SAIL by 'dedd reckoning.' This was the cause of the great disaster in 1701 when the Mediterranean Fleet, running before a westerly gale found itself suddenly, and at night, amongst the rocks off the Isle of Sicily. Charts at that time were also inaccurate which led to countless losses of crews and cargoes. Authorities in Spain, HOLLAND, AND France also scrambled to find accurate methods of finding latitude and longtitude at sea.

John Harrison emerged as one of the early pioneers in making a time piece which would run accurately on board a rolling and pitching ship. A Board of Longtitude, appointed by Parliment, advanced funds to Harrison, as did the E. India Co. during the five years it took to build the first sea clock. However, another 19 years elapsed, now 1761, and at the age of 68 years , having lived in poverty, before HARRISON came up with a sea clock ready for testing. So, on Nov. 18, 1761, Harrison's son set sail on a square rigger, HMS Deptford from Portsmouth, with the watch resting on a pillow, an astronomer observing, and bound for Jamaica. Ten days out, the Capt. was not certain if he was E. or W. of Maderia. Harrison was able to calculate that they were still 100 miles to the W., and also gave the time at which they would sight another ISLAND, Harrison was correct. Upon arrival in Jamaica, the astronomer set up his instruments. To win the £-20,000 prize the watch had to be not more than one minute, 54 sec. out, after 81 days, rough passage, and extreme temperatures. The watch was found to be only 5.1 sec. off, or the equivalent of 1 1/4 miles. After much frustration, due to innumerable Govt. delays, Harrison was finally paid a total of £-18,750, plus grants of £-4000, but he was then 80 yrs. of age, and died three years later.

Pierre LeRoy in France was also doing parallel work, and made valuable contributions to the development of a practical marine chronometer.

The broad casting of GMT by radio, revolutionized navigation. It was the ideal method of checking a chronometer at sea. Today, developmentsof sophisticated navigational equipment are rendering chronometers less essential..

To go along with the development of time pieces, there had to be means of recording the passing of time. So, we should have a little exploring of early calendars. Man "mapped" the year many centuries before he got around to clocking the day. The earliest reckoning of time must have been in the terms of "suns," Some kept account by cutting notches in a stick of wood, or by making marks on the walls of caves. The moon was also used, and when man finally invented a method of counting, he discovered that approximately twenty-nine suns elapsed between successive full moons, and that the time between identical phases of the moon never varied. Stars, too, moved across the night sky in what appeared to be well-established patterns. The Egyptians came along with one of the earliest calendars, employing 12 months, each of which had 30 days. The astronomers were aware that the resulting 360-day year was too short and that it did not exactly agree with the seasons. To take care of that difference they added five feast days at the end of the year. But the 365 day year was still too short by 1/4 of a day; the 1/4 of a day each year can accumulate to 25 days in a century.

However, Ptolemy III, who was KINg of Egypt in 238 BC was a well informed man with a progressive mind. To keep the calendar in rhythem with the seasons, he proposed adding a day to the 5 end-of-the-year feast days every fourth year. In spite of the King's edict, it was two centuries before the idea of a quadrennial leap-year day received the recognition it deserved-- and, then by Julius Caesar in 63 BC.

And so we continue to consult the calander we inherited from Julius Caesar by way of Emporer Constantine, and Pope Gregory XIII. Schemes for redesigning the Gregorian calendar began as long ago as 1834, when a plan for a universal calendar was produced by an Italian priest, Abbe Matrofini. Between that year and 1930, hundreds of calendar schemes were devised. But it was not until the autumn of 1930 when the WORLD Calendar Assoc., INc., was founded by Elizabeth Achelis, that a really satisfactory calendar was offered. This World Calendar is a masterpiece of mathematical ingenuity. Some members of United Nations are enthusiastic about this World Calendar, Our country shows little interest, although an accurate calendar is after,all, essential to an orderly world society. It seems strange that we strive continually to refine our clocks to millionths of a second, and yet remain content, by and large, to get along with a calendar that is antiquated and confusing.

As some of you may have read, this past June 30 was a very unusual day. It was unusual in that a minute was stretched to 61 sec., and in so doing we had our longest day. We can blame it on the earth's inconsistency. Its rotation has slowed by 10 sec. just since 1958, but astronomers inform us that it may someday start speeding up again. One theory attributes this difference to a random sort of sloshing around of material in the earth's core. Government members of the International Radio Consultave Committee, who help time headquarters in Paris set regulations, have sworn an oath never to let astronomical time get more than 7/10 of sec. out of whack with atomic time. The atomic clock at Nat'l. Bureau of Standards time headquarters in Boulder, Colo., controls the tock, tock, tock broadcast from WWV at nearby Fort Colllins. Time kept at Boulder and by atomic clocks all over the world is subject to continued comparison of global time headquarters, which is at the Bureau Internationale de L'Houre in Paris. The one second correction by the way, meant adjusting clocks around the world. The Naval Observatory in Washington, notified the six Navy radio stations scattered around the world, and precision atomic clocks at more than 25 Nat'l. Aeronautics and Space Admin. tracking stations had to make this adjustment. The Smithsonian Astrophysical Obsertavtory in Cambridge, Mass., sent a bulletin to its 12 satellite tracking stations ordering a synchronized change to all of its clocks. The time which is broadcast is always in Greenwich mean time (GMT). Incidently The signal from WWV at Fort Colins is ever helpful to violin players for once each hour a brief tone of 440 cycles, or A above Middle C is given out.

As a further development in the many efforts to improve time keeping, the first atomic clock was built by the Nat'l. Bureau of Standards in 1948-49. This device utilized the invariable natural vibration that occurs inside the ammonia molecule, which may act as a regulator for a quartz-crystal oscillating system of circuits. The ammonia clock is complciated and rather a clumsy machine, but its accuracy is phenominal. For example, if we say a watch runs slow by a second a day, it has an error of one part in 86,400(seconds in a standard day). The ammonia clock keeps its measurements of time constant to one part in 100 million; continued improvements have meant the clock might lose but one second in one to two hundred years. Along with the ammonia sē-zē-em

clock, another atomic clock employing the use of vibrations of CESIUM atoms as a master governor. Cesium is a rare silvery metal. Atomic clocks are not time pieces we would be likely to install in our living rooms. The cesium clock for example weighs about 500 lbs., and costs in the neighborhood of $500,000.

Should any of you be interested in a quartz-crystal watch, let's take a look at what is available. Bulova introduced the Accuqartz on Dec. 6, 1971, with a crystal that twangs 32,768 a second, for a price of $395 in gold, or $250 in stainless steel. Timex plans to introduce a similar type for $200; Hamilton has the Pulsar which guarantees accuracy to within 60 sec. per year, and is modestly prices at $2,100 Omega has a prototype quartz-crystal wrist watch which beats over 2 million times a second. In these quartz-crystal watches there is little to go wrong for when quartz crystals are stimulated electronically they vibrate like a guitar string being twanged-- anywhere from 1,000to 10 million times a second. As long as the current keeps flowing, the quartz goes on twanging at the same rate. The oscillations are counted by a miniature computer which signals the precise instant for the second hand to move a notch.

At stake is a world wide market which currently consumes about 160 million pieces a year, and is expected to reach 300 million by 1980. Right now there is no telling whether the Swiss, Japanes, or Americans will lead the field.

On the practical side concerning atomic clocks, we can say that they will establish a standard of time that will be quite indepndent of the motions of the earth and stars. It would allow for extremely fine fixes in ship and aircraft navigation, as well as play an important role in exploration of outer space. The atomic clock is of recent invention-- a newcomer to the fields of science. It is a tool for research and discovery, rather than a clock for telling the time of day. To scientists its uses are many and exciting. In years to come it may well be instrumental in helping us to a broader understanding of our intricate universe. It is only a question of time!