ASTRONOMY

On Time

Clocks and Sun-Dials Fail to Keep Step Because of Variations in Speed and Direction of Earth's Motion

By JAMES STOKLEY

ONE of the oldest of time-keeping devices is the sun-dial, which existed, in a primitive form, among the ancient Egyptians. Even when mechanical clocks came into use, about the middle of the 14th century, the sun-dial was not immediately displaced because the first clocks were extremely crude. One that was accurate to within an hour a day was considered extraordinarily good. In 1658, however, the Dutch astronomer, Huygens, introduced the pendulum for controlling clocks and the accuracy was immediately vastly increased.

Then the errors of the sun-dial became more apparent. It was found that the clocks and dials did not keep in step, but sometimes one was fast, sometimes the other. This was true for an accurately running clock, that is, one which always showed the same length for the hour or any other unit of time. If you have a sun-dial available and can compare it with an accurate watch, you will find that this month, on Feb. 11, the watch is 14 minutes 23 seconds fast of the dial, greater than at any other time of the year. This is not the greatest difference between the two, however, for on November 3 you will find that the dial is fast by 16 minutes 23 seconds.

Equation of Time

This constantly varying difference between the clock and dial, known technically as the "equation of time," is a result of two things. First, the equator of the earth, the line at right angles to the axis on which it spins, is not in the same plane as the path in which the earth encircles the sun once a year. Secondly, the earth does not maintain the same distance from the sun as it goes around it.

If it were possible to see the stars and the sun at the same time, and we looked at them each day, we should find the sun gradually moving eastward among them. This is an effect of the annual motion of the earth in its orbit, and gives us two different kinds of time, depending on whether we take it from the stars or the sun. The former is called sidereal time, and is used only by the astronomer.

The difference between them can be understood if we think of the sun and a certain star being in exactly the same direction, and directly south; the hour is 12 noon. Because of the daily spinning of the earth they both seem to move across the sky from east to west, and after one turn of the earth they are south again. But in this time the earth has also moved about one three-hundred-and-sixty-fifth of its journey around the sun. The sun therefore has apparently moved eastward from the star, they are no longer in the same direction. Consequently, the earth has to turn about four minutes longer before the sun again is south or on the meridian. Thus the solar day is about four minutes longer than the sidereal day.

Varying Rate

Because of the angle between the earth's equator and its path around the sun, that body does not move eastward at a uniform rate. In June and December it is moving directly east—all its motion is used in causing a delay of its crossing the meridian. But in March it is moving northwards as well; and in September it is moving to the south, hence it does not travel to the east as rapidly and the delay is less.

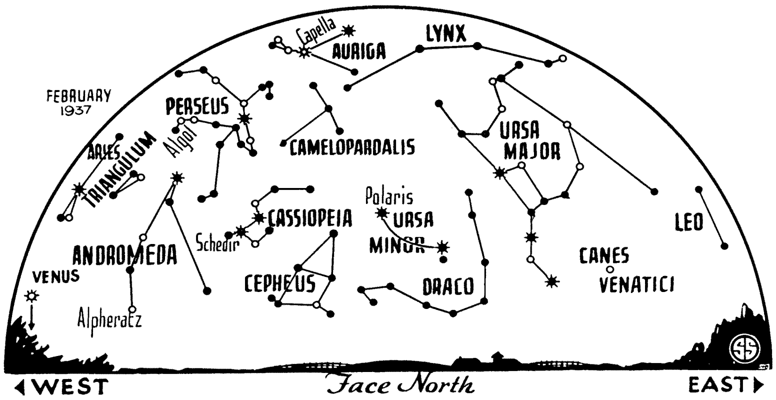
This is one factor. The other is a result of the fact that the nearer the earth is to the sun, the more rapidly we move in our orbit. In January, therefore, when the sun is nearest, we move around it at a faster rate than at any other time of year. The earth, then, goes farther in its orbit while it turns once, the apparent daily motion of the sun to the east is greater, and the delay in crossing the meridian is greater.

Long at Christmas

These two variations combine in such a way that the longest day (as measured from the time it takes the sun from one meridian crossing to the next) comes about the time of Christmas. Then the day is nearly half a minute longer than average. In September it is shorter than average by almost the same amount. From the middle of February to the middle of May, and from the end of August to the beginning of November, the days are short. During the rest of the year they are long.

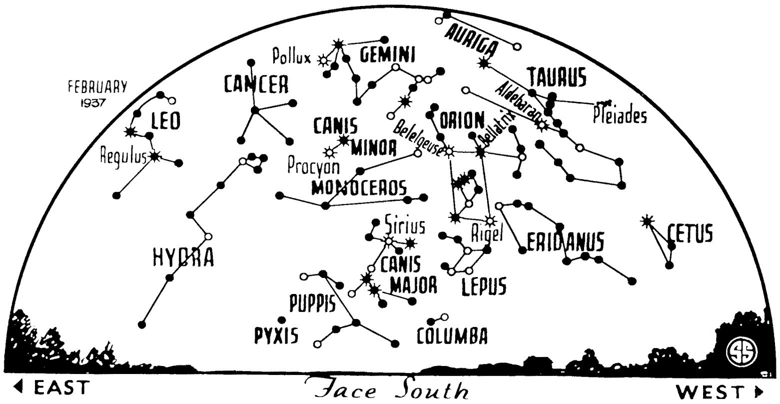
Now we can understand the effect on the clocks, and why they differ from the sun-dial. About Christmas Eve, the two were together, but the solar days were very long and each day the sun dropped behind a little, so that they got more and more out of step. Now the days are still longer than average and the clock is still gaining on the sun. On February 11, however, the day will

☼ ✱ ○ • SYMBOLS FOR STARS IN ORDER OF BRIGHTNESS



INCREASING BRIGHTNESS

Venus shining in the west after sundown will grow more brilliant as it draws nearer until March 12 after which it will rapidly fade as it comes between the earth and the sun.



SIRIUS

Brightest of the stars is the dog-star in Canis Major.

be just 24 hours in length, and after that it will be shorter than average. Then the sun will gain on the clock. This continues, back and forth, during the year. The result is that the clock, during 1937, is ahead from the beginning of the year to April 15. The sun is ahead from that date to June 13 when the clock is again in the lead. But it does not hold it for long. On September 1 the sun takes the lead, gaining until November 3. After that it starts losing, but the clock does not get ahead until Christmas Day. These dates differ slightly from one year to the next, but they are typical.

Of course, it would be possible to make a clock that would gain at certain times of year and lose at others, and, in fact, they have been constructed. But it is much more convenient to have one that runs always at the same rate, so that an hour in December will be the same length as one in September, and that is the way our clocks operate. On the other hand, the ingenuity of inventors has resulted in several sundials that indicate clock time, but, like all of their species, they only work in sunny hours.

Most Conspicuous

The most conspicuous object in the evening sky during February will be the planet Venus, shining in the west. For several months it has been drawing east of the sun, and on February 7 will be at its greatest distance, setting longest after sunset. Then it will approach the sun again, but it will continue to brighten, for, at the same time, it will be swinging around on the side of the sun nearest the earth. At the beginning of February, its distance is some 66,000,000 miles, but on March 1 it will be less than 40,000,000 miles away. As it gets nearer, its brightness increases, until March 12, after which it will rapidly fade as it comes between the earth and sun, lost in the glare of the latter body.

Since Venus is a planet like the earth, its only light comes from the sun, and at the same time the illuminated hemisphere will turn away from us. At 5:50 p.m., Eastern Standard Time, on February 14, the moon, then a young crescent, passes Venus, about 6 moon-diameters to the north. On the evening of that date the two objects will form a striking sight.

Saturn Visible

Saturn is also visible in the evening next month, though nearer the sun than Venus. It is not indicated on the maps because it sets earlier than the hours for which they are drawn (i.e., 10:00 p. m. on February 1, 9:00 p. m. on the 15th, and 8:00 p. m. on the 28th). But if you look to the west, about 7:00 p. m. at the beginning of the month, you will see it almost directly below Venus. It is considerably fainter, though brighter than any star in that part of the sky. As for the other planets, Mars, prominent on account of its red color, appears in the east soon after midnight. Jupiter, towards the end of the month, will be visible low in the southeast, just before sunrise. Mercury will be a morning star, visible in the eastern twilight before dawn, for a few days about the 7th.

The stars, each one a glowing globe of gas, like our sun but millions of times farther away, shine brilliantly this month. Brightest is Sirius, the dog-star, in Canis Major, the great dog, to the south. Above and to the right is Orion, the warrior, with two first magnitude stars, Betelgeuse and Rigel, as well as a number only slightly less conspicuous, such as the three in a row that form the warrior's belt. Still higher and farther west is ruddy Aldebaran, in Taurus, the bull.

Above Canis Major is Canis Minor, the lesser dog, with Procyon, and above him are the twins, Gemini, with bright Pollux. Almost directly overhead, at the times of the maps, is Capella, in Auriga, the charioteer. The eighth star of the first magnitude now visible is to be seen in the east—Regulus, marking the constellation of Leo, the lion.

The familiar great dipper stands in the northeast, its handle downwards, and the pointers, indicating the direction of Polaris, the Pole Star, above. Cassiopeia, the queen, shaped like a letter W on its side, the top to the right, is at about the same height to the northwest.

During February the moon is farthest from the earth, or at "apogee," on February 3, at 7:00 a. m., with a distance of 251,220 miles. It is closest, at perigee, on the 15th, at 3:00 p. m., 229,290 miles from us. Its phases are indicated below:

Phases of the Moon

		Eastern Standard Time
Last Quarter	Feb. 3,	7:05 A. M.
New Moon	Feb. 11,	2:34 A. M.
First Quarter	Feb. 17,	10:50 P. M.
Full Moon	Feb. 24,	2:43 A. M.

Science News Letter, January 30, 1937

PHYSICS

Notre Dame University Has New Atomic Gun

See Front Cover

AN electrostatic type of high voltage generator with which scientists hope to create the tiny elemental particles known as positrons has now been installed at the physics laboratories of the University of Notre Dame. Under the direction of Prof. G. B. Collins, two graduate students, R. J. Schager and A. L. Vitter, have built the giant apparatus shown on the front cover of this week's SCIENCE NEWS LETTER.

Voltage is conveyed up to the large 12-foot diameter electrode on the belt in the foreground. The accelerating tube down which electrons will be driven by the 1,500,000 volt potential is at the left. The size of the equipment is realized by comparison with the scientist standing below.

Science News Letter, January 30, 1937