THE FOURTH DIMENSION

A topic not neglected by science fiction writers is the mysterious fourth dimension. We have no difficulty in appreciating one dimension as a line ; two dimensions as an area ; and three dimensions as a volume. Most of us are prevented from formulating an idea of further dimensions as we have no experience of them. We can try to establish what form a fourth dimension figure would take by analysing figures in the dimensions we understand.

Fig. 1
1 dimension

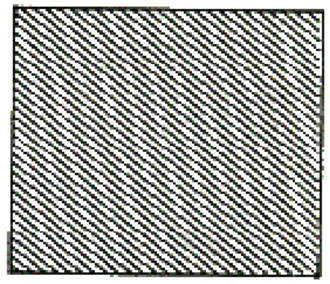


Fig. 2
2 dimensions

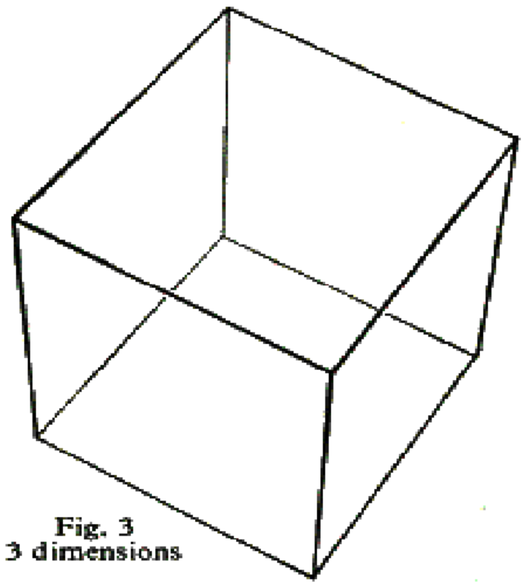


Fig. 3
3 dimensions

Fig. 3 represents a cube : it is not a cube, of course, because it is constructed in the two dimensions of this page! With the distortion of 90° angles to give an optical illusion of perspective, it is a two-dimensional representation of a three-dimensional cube.

Surely then, we should be able to represent a four-dimensional 'cube' by distorting a three-dimensional one! From the sequence of diagrams, it follows that our model will have four struts originating from each vertex. It can be constructed quite easily from pipe cleaners and milk straws (the new narrow plastic ones are ideal). Cut the pipe cleaners into lengths of about $1\frac{1}{2}$ in. Make sixteen vertex supports, each with four arms, by winding these lengths together in pairs. Bend the arms in the directions indicated by fig. 4.

Construct the 'outer cube' by pushing twelve 4 in. lengths of straws on to the vertex supports. Similarly, construct the 'inner cube' from twelve 2 in. lengths. Finally, eight 2 in. lengths. will support the smaller cube within the larger. (It may be necessary to reduce these dimensions by $\frac{1}{10}$ in. to allow for jointing at the vertices).

The completed model is a three-dimensional representation of a four-dimensional 'cube.'

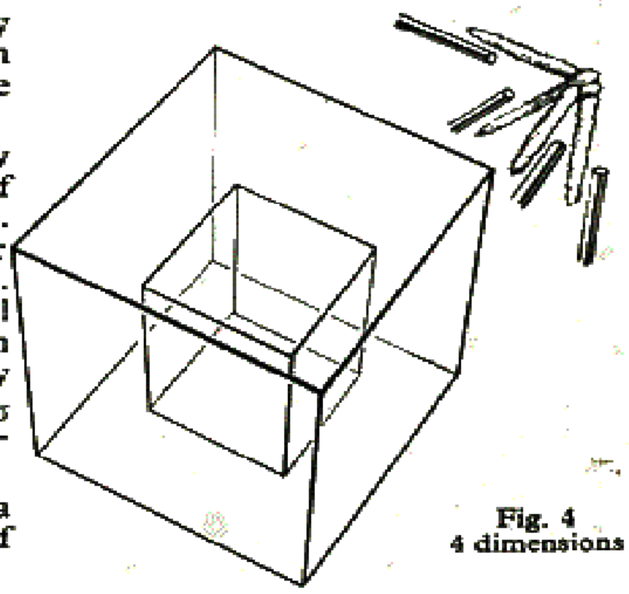


Fig. 4
4 dimensions

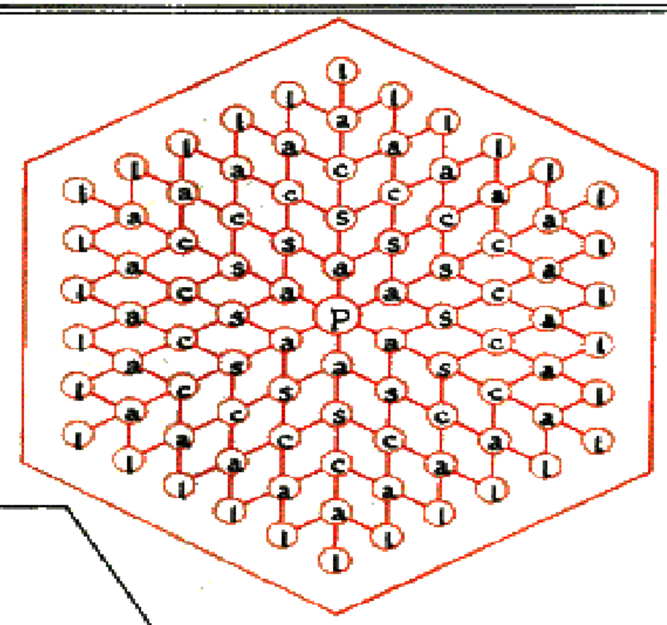
56672 27966 19885 78278 2 gives π to 10,022 figures.

mathematical pie

No. 51 — *Editorial Address :* 100, Burman Rd., Shirley, Solihull, Warwicks, England — MAY, 1967

P-A-S-C-A-L

You have heard of Pascal's Triangle ? Well, here we have him in a different figure—a hexagon. In how many ways can you spell out the name Pascal in this figure starting from the centre P and working outwards to the edges ? R.M.S.



A CERTAIN SMALL ISLAND

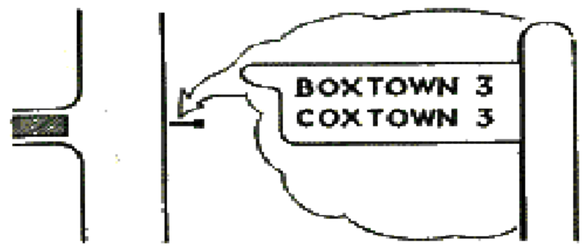
A certain small island was colonised, one church facing east, as shown, served four religious sects. After a time, the sects decided that they must each have a church. Of these, three had to face west and one east. Show how the church can be divided up to please them all. J.F.H.

WHERE ARE THE TOWNS ?

While driving along, I came across a signpost as shown in the illustration.

There was a lorry blocking the side road, so it was not possible to see whether it branched immediately or later on.

Can you sketch the area in which the two towns could lie ? J.F.H.



20542 74628 65403 60367 45328 65105 70658 74882

OOPS-A-DAISY

Mr. Miller, his wife Daisy, and their son Dusty live in one of the few remaining windmills. Their living quarters are on the top floor. One night they awake to find that the lower part of the mill is on fire and the staircase is impassable. Outside one window is a pulley with a rope round it which is used for hoisting sacks of corn. Using this and a sack of potatoes from the kitchen they all manage to reach the ground safely. If the difference between the weights on the two ends of the rope is more than 15 lb. the descent would be too dangerous for a person. Mr. Miller weighs 195 lb., his wife weighs 165 lb., and Dusty weighs 90 lb. If the sack of potatoes weighs 75 lb., how did they arrange their escape? R.M.S.

HAVE YOU TRIED THIS?

Have you ever noticed how shadows decrease and lengthen during the course of the day, or wondered how the length of a shadow is connected with the time of day? An easy experiment with shadows will give you some very interesting results, but you need a clear, sunny day to do it.

Find a place in the garden or on the playing field that is never in the shade during the day and stick a garden-cane in the ground so that it stands up vertically. Starting as early as you can, measure the length of the shadow once every hour until it is no longer clear enough to give an accurate measurement. The next step is to make a graph of your measurements by plotting the length of the shadow against the recorded times and joining the points as smoothly as you can. This should give you an interesting curve. I.L.C.

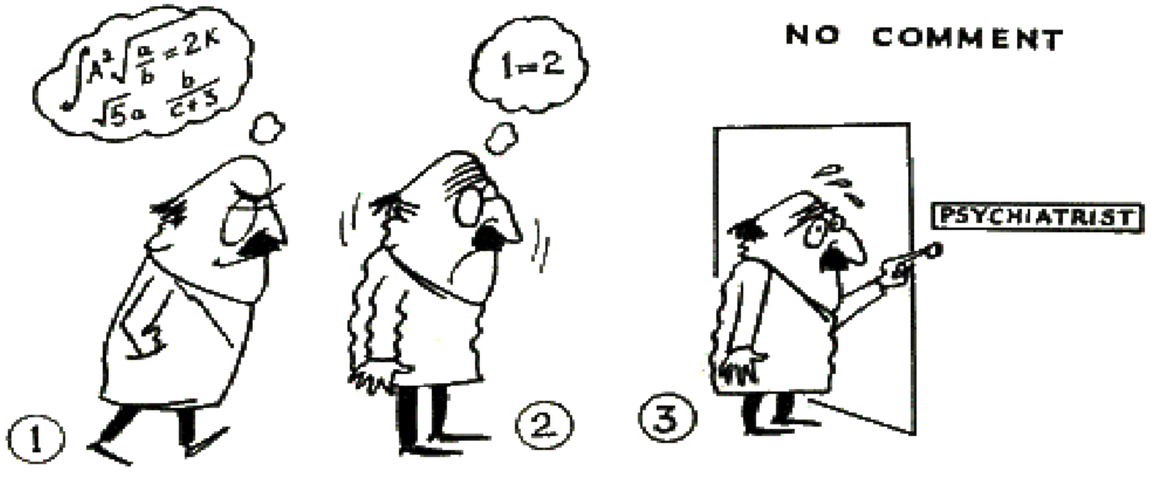
WHEN PAINTING MY HOME

When painting my home, I placed the top of the ladder against the gutter. I found that the height of the gutter was 1 foot less than the length of the ladder and that the horizontal distance from the foot of the ladder to the wall was 8 feet less than the length of the ladder. How long was the ladder? D.I.B.

100 TREES

100 trees are planted at the corners of a square lattice, each square having sides of 6 feet. A bullet is fired from one corner of the plantation at 30 degrees to one edge. How many trees will be hit? Euclidean trees and bullets are used, *i.e.*, they have no size. L.T.A.

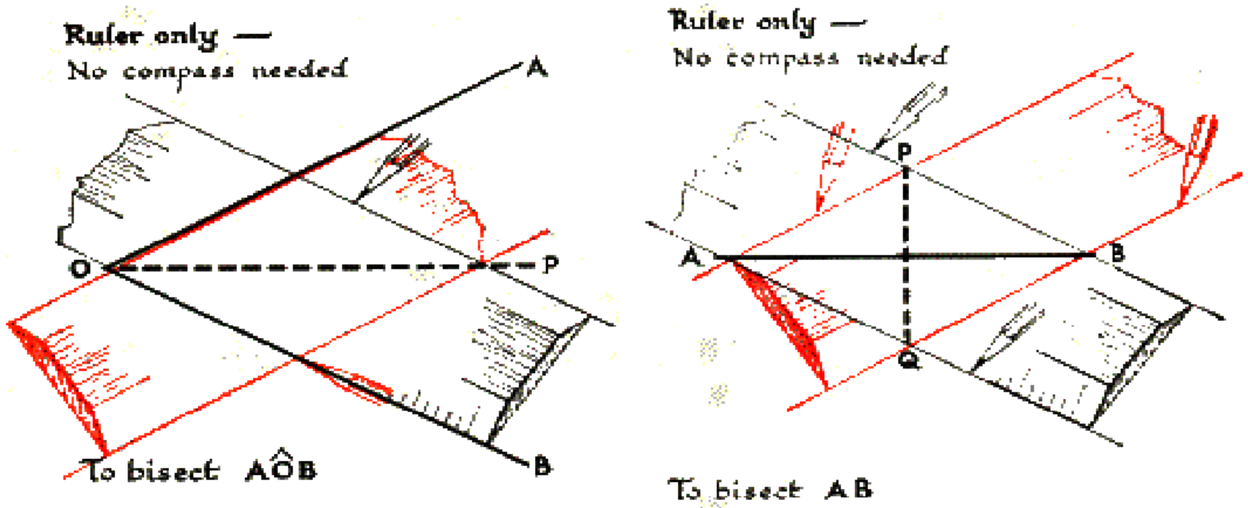
NO COMMENT



In the U.S.A. the confusion was even worse. A conference in 1884 suggested a set of " time zones " in each of which the standard time should be an exact number of hours different from G.M.T. By 1912 this was adopted by most countries and in 1966 only Liberia does not base its time on G.M.T. C.V.G.

SOLUTION TO PROBLEMS IN ISSUE No. 49

BAND CONSTRUCTION



SOLUTION TO PROBLEMS IN ISSUE No. 50

SENIOR CROSS FIGURE No. 47

CLUES ACROSS: 1, 8137; 4, 47; 5, 21; 6, 13; 7, 714; 8, 493; 10, 125; 11, 165; 13, 239; 15, 29625; 17, 44; 18, 39.

CLUES DOWN: 2, 121; 3, 314159; 4, 439; 6, 14522; 7, 781; 9, 389; 12, 624; 14, 353; 16, 64.

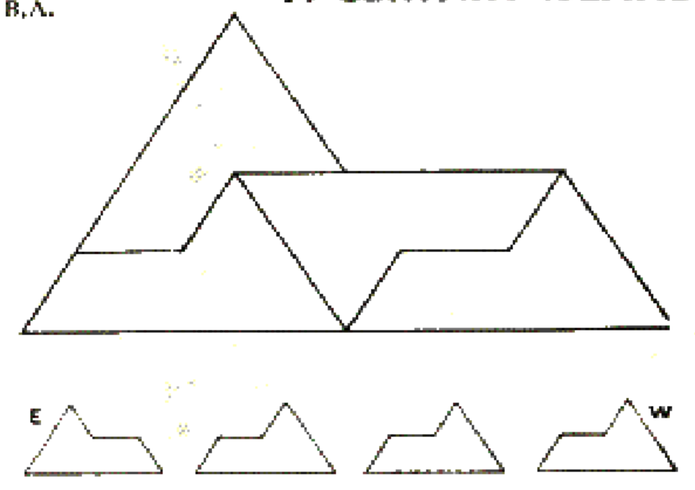
ISSUE No. 49 PROBLEMS

General Taikoff found that the Yuffels of Alpha Centauri count in threes: " = 1, . — = 1, : = 0. Many readers found this and book tokens have been sent to:— C. Mateby, Solihull; C. M. Booth, Pinner; Mrs. Bishop, Sponden; J. Miserloign, London; S. Savage, Edinburgh; R. M. Dixon, Leicester.

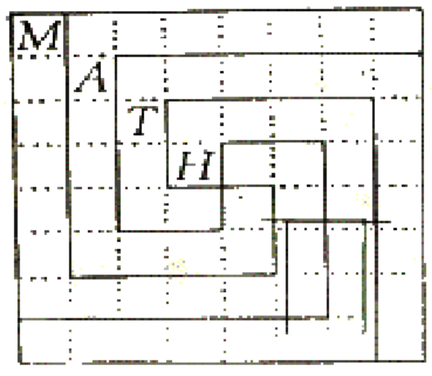
B.A.

SOLUTION TO PROBLEM IN ISSUE No. 51

A CERTAIN ISLAND



CUTTING UP THE PIE



Continued from page 401

and every two weeks the dial was changed. With natural hours there are twelve hours of daylight and twelve hours of darkness but as the hour hand turns at an even rate the daylight hours use less than half of the winter dials and more than half of the summer dials.

It was not practical to have one system of time for sundials and another one for clocks so, in the fourteenth century, the modern form of sundial with its gnomon parallel to the axis of the earth was introduced.

To understand the reason for this we must understand the reason for the variation in the length of daylight from winter to summer. Because the earth turns on its axis the sun appears to travel in the sky in a circle round the earth. At the equinoxes in March and September when the sun is in the plane of the equator we can see just half of this circle so night and day are of equal length. Because the axis of the earth is not perpendicular to the plane of its orbit around the sun the circle seems to move nearer the North Pole in the summer so that we see more than half of it, and further away in the winter so that we see less than half of it.

The simplest form of "even-tempered" sundial is the "Dutch" sundial which has the gnomon parallel to the axis of the earth and the ring on which the hours are marked fixed parallel to the equator. The shadow of the gnomon moves round the hour ring at the same rate as the sun moves round the sky. Although the Dutch dial is the easiest to understand, it is not the easiest to make. This is the horizontal garden type or the wall type in which the hour marks were projected onto horizontal or vertical surfaces by using marking cylinders. These had twenty-four equally spaced lines on the dials to be marked, the axis of the cylinder was parallel to the axis of the earth.

Before the introduction of magnetic compasses, a sun dial which depended on the direction of the sun had to be a fixture. Portable dials had to depend on the height of the sun. In the Middle Ages the pocket dial looked rather like a napkin ring with a hook at the top and a small hole in one side. When the ring was hung with the hole towards the sun, a spot of light fell on the scale of hours marked inside the ring. Different scales were provided for different times of the year. The "shepherds clock" which survived in country districts in Europe until this century, consists of a cylinder with a horizontal pointer. The pointer is set towards the sun and the cylinder turned until the shadow's tip touches a scale on the surface of the cylinder. As the sun is higher in the sky in summer than it is in winter the cylinder has different scales for different seasons of the year.

Accurate pendulum clocks introduced a new difficulty. Because the earth's orbit is elliptical the apparent speed of the sun through the sky is not constant. A fictitious "mean sun" moving with constant speed became the basis of Greenwich Mean Time in 1738. The real sun can be 15 minutes in front of the mean sun.

G.M.T. was used for the Nautical Almanac but for ordinary purposes local time was used. This caused difficulties with the coming of the railways. Local times at the start and finish of a journey might differ by a quarter of an hour. Each railway company adopted its own "railway time," station clocks had two minute hands, one for railway time and one for local time. This confusion persisted until G.M.T. was made the legal time in 1880.

92764 57931 06579 22955 24988 72758 46101 26483

A WINDOW CLEANER'S PROBLEM

AB is a house with a window at A 40 ft. above the ground, CD is a house on the opposite side of the street and C is a window 30 ft. above the ground. A ladder OA just reaches the window A and if turned through 90° about O just reaches the window C. How long is the ladder and how wide is the street BD?

AB IS THE HYPOTENUSE

AB is the hypotenuse of a right angled triangle ABC. AB is 4 inches long and the ratio of the length of the side BC to the side CA is 1 : 2. Show a simple way of constructing the triangle without using the angle in a semi-circle.

J.F.H.

SENSE OF TOUCH NEEDED

Three non-intersecting circles are drawn on paper. How many circles can be drawn to touch all three?

Given the following lengths, namely 6 cm., 10 cm., and 12 cm., construct a trapezium with parallel sides 6 and 10 cm. and diagonals 10 and 12 cm. using compass and straight edge only.

HAVE YOU EVER BEEN ADD?

Do you want to increase your reputation as a lightning calculator? Here's how! Get a friend to write down two numbers less than twenty, one under the other without letting you see them. Now tell him to make a third number by adding the first two together and write it below the first two. Now he must make a fourth number by adding, the second and third, a fifth by adding the third and fourth, and so on, until he has a column of ten numbers. Now ask him to show you the column of ten numbers and immediately you write down the total underneath—in the example this is 891.

5	
7	
12	
19	
31	
50	
81	
131	
212	
343	
891	

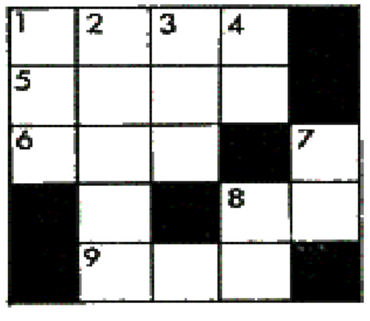
The clue is to look at the seventh number, here 81, and multiply it by 11. Why does it work?

R.M.S.

JUNIOR CROSS FIGURE
No. 43

Suggested by David Holbrook, Dulwich, London.

Ignore decimal points.



Clues Down:

1. $\sqrt{145161}$.
2. tan 58°2'.
3. One quarter of a mile in yards.
4. Eleventh prime number.
7. Number of inches in one metre.
8. The sum of the first five natural numbers.

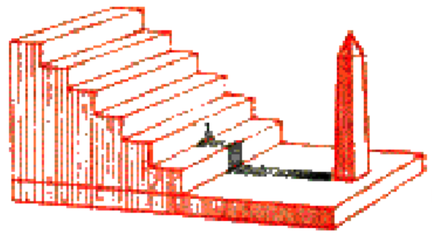
Clues Across:

1. π.
5. 93^2.
6. Nine in the scale of three.
8. A solid wooden box 10 cm. by 8 cm. by 7 cm. weighs 1064 grammes. Find the specific gravity of the wood.
9. The area in square feet of a circular path one yard wide surrounding a circular lawn of radius 20 feet.

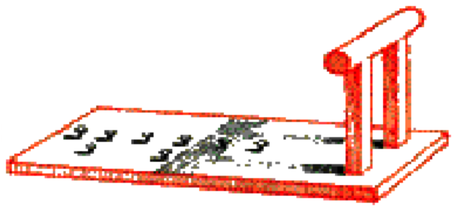
S.T.P.

50201 41020 67235 85020 07245 22653 26513 41055

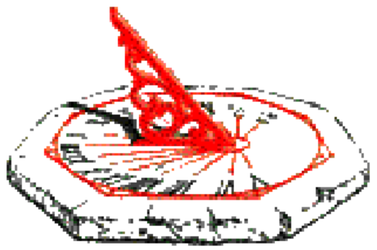
To Tell The Time



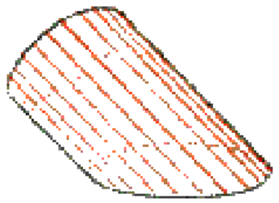
Egyptian temple steps
circa 2000 B.C.



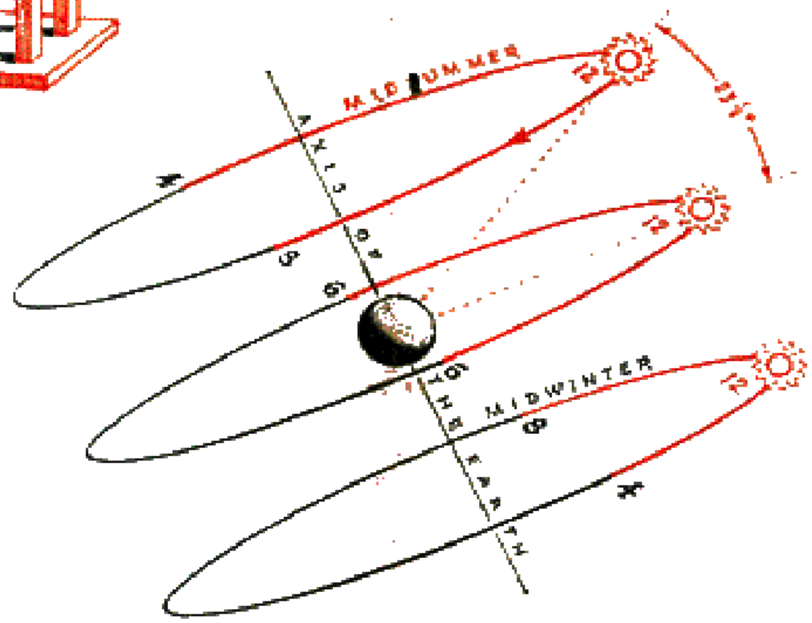
Egyptian time piece
circa 1020 A.D.

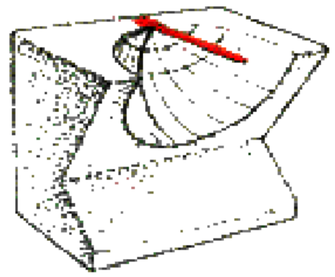


Even tempered dial *1341*

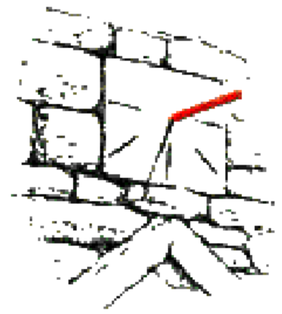


Marking cylinder

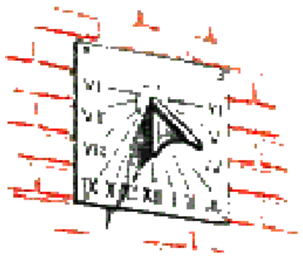




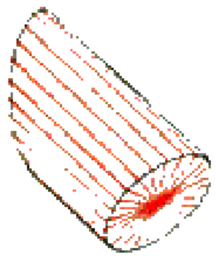
Greek sundial



Saxon dial

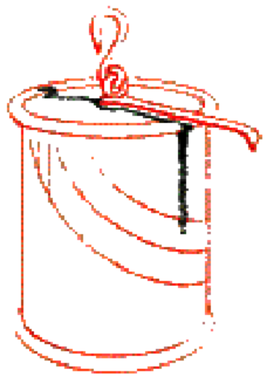


Wall dial

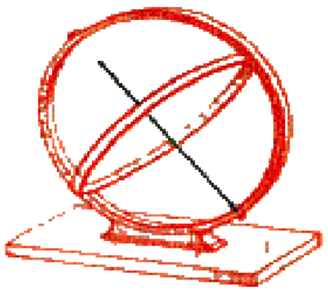


Marking cylinder

Pocket dial



Shepherd's clock



Dutch dial

Summer Winter

Japanese clock

Station clock

Thousands of years ago, the priests of the Egyptian temples judged the time by watching shadows on their temple steps. This lead to the " step clock " which was a portable model of a flight of steps and an obelisk. It was placed with the " obelisk " towards the sun. At sunrise the shadow of the obelisk just reached the highest step. As the sun rose higher, the shadow shortened until at midday it reached only to the bottom step. Then it climbed once more as the sun declined. " Clocks " of this type survived until this century, but tin tacks were used instead of model steps.

The Greek sundial was shaped like a hollow quarter sphere divided into twelve sectors. The sundial was fixed facing south and as the sun travelled through the sky, the shadow of a horizontal gnomon, or shadowstick, moved over the surface. The day, from sunrise to sunset, was divided into twelve equal hours. Midday was the sixth hour and the sunset at the twelve hours. As the summer hours were much longer than the winter hours it is as well that there were no speed limits in ancient times

A simplified version of this which was used in early mediæval times can be seen above the south porch of many old churches. This had a horizontal gnomon with hour graduations radiating from it cut into the wall. Often the only hours marked are the third, sixth and ninth, when the services " tierce," " sext " and " nones " were said.

When the first clocks were introduced at the end of the thirteenth century it was impossible to make them show natural time. They ran at the same speed night and day, so a system of even tempered hours had to be introduced. A day and a night together were divided into twenty-four equal hours. The first clocks in France and Italy were set at XII at sunset but in England, where the evening sun is often obscured, they were set at XII at midday and this system was generally adopted.

In Japan, where even tempered hours were not used until 1886, clocks with twenty-four hour dials were used. Each clock had a set of dials

Continued on page 402