

sharp file cut off a definite length, say 50 mm., of the tube and divide the contained sodium with a knife. Weigh the piece so removed, throw it into water and then weigh the glass after washing and drying. This gives you the weight of sodium in 50 mm. of the tube. Now cut off in the same manner the length calculated to contain 23 mg. of sodium and put it in the tube A. Either of these methods of getting a determinate weight of sodium is much easier and also more accurate than it sounds. There is no trouble in obtaining an amount within 0.5 mg. of that desired. The glass tube falls with the sodium wire into the water with which the tube A is charged, the glass preventing the sodium from sticking on the way down. The three sets of apparatus must be prepared before the lecture and set up side by side in a suitable holder. The actual experiment does not require more than six minutes, and the volumes of gas evolved are in the ratio of 1:2:3 as accurately as can be desired or expected in such an experiment. It would be well if the acid could be colored by some dye, so as to be more easily visible in a large lecture room; in a small one no such device is needed, but all dyes tried are bleached, either by the aluminum or by the sodium.

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## OBSERVATIONAL WORK CONNECTED WITH ALMANAC DATA (II).

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Like all other laws of nature the law of change of length of the day, discussed in my November paper (page 281), derives its chief value from its relations to other natural laws. It is important that the pupil should get clearly in mind not merely that the length of the time the sun is above the horizon varies from month to month for the same latitude and from latitude to latitude for the same month; but he must also be led to realize, in this connection, the effect of the varying slant of the sun's rays. A very satisfactory way of approaching this question with a high school class is by the aid of an instrument like the one shown in the

April number of the MATHEMATICAL SUPPLEMENT of SCHOOL SCIENCE (page 32) called the *helios* by Dr. H. B. Loomis, or by means of the still simpler form devised by Mr. W. S. Jackman, of the School of Education, University of Chicago, and shown here. Mr. Jackman calls this form of the device the *skiameter*. (Fig. 1.)

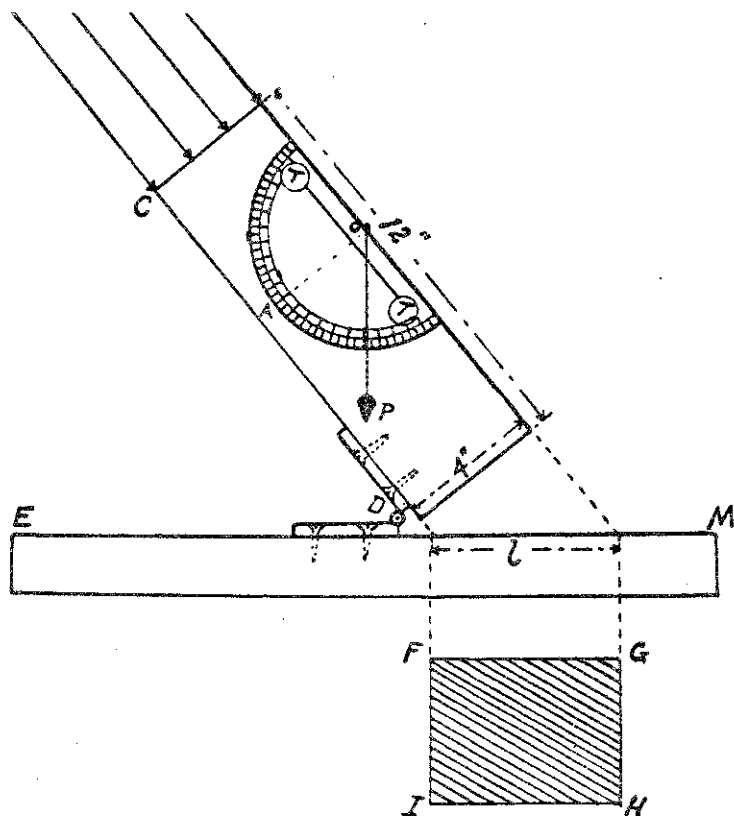


FIG. 1.

A right-prism,  $CD$ , of wood  $4 \times 4 \times 12$ ", is hinged to a baseboard,  $EM$ , at  $D$ . A protractor and small plumb-bob are pinned to the side of the prism as shown.

The baseboard should be leveled by placing a round marble upon it and the prism pointed toward the sun so as to make the shadowed rectangle at  $l$  as small as possible. The illuminated

rectangle of the skiameter has been replaced here by a shadowed rectangle (shown at *FGHI*) 4" wide and of varying length, depending upon the slant of the sun's rays. There will be no difficulty in getting the pupil to understand that the shadowed rectangle is the surface that would, if the prism of the skiameter were removed, be illuminated and heated by the square prism of rays of the same cross-section as that of the skiameter prism.

Since every other equal area of the horizontal surface of the earth is heated and lighted in the same degree as the shadowed rectangle would be, if the sun's rays were unobstructed, this shadowed rectangle may be used as a standard for estimating the heating (or lighting) effects of the sun's rays. Since the definite quantity of light and heat intercepted by the prism, which is set to point directly toward the sun, is, under normal conditions, spread over the shadowed rectangle, it is clear that a given unit of the area—say one square inch—is heated and lighted with an intensity which varies inversely as the area of the rectangle varies. The intensity of the heat, or light, which means the amount of heat (say in *calories*) or of light (say in *candle-power*) per unit of heated or illuminated area, and may at first be spoken and thought of by the beginner as the *depth* or *thickness* of heat or light.

The width of the rectangle always remaining 4", its area will vary directly with its length. Consequently the *lengths* of the rectangle, which are measured, may be taken as standards for comparing the intensity of the heating and lighting of the surface as depending on the varying slant of the sun's rays from time to time. Here is a good opportunity to teach "Rectangles of the same width are as their lengths." The slant of the rays may be read directly from the protractor as the angle, *AOC*. Why is the angle *CDE* equal to the angle *AOP*? Here is the place to teach angle as the amount of turning of a rotating line—also the angle and arcual degree.

The values of the slant and of the lengths of the rectangles read from hour to hour for October 27, 1903, are given in columns two and three, respectively, of the table.

The observed values of the slant, shadow-lengths, and inten-

sities corresponding to each hour from 7:00 a. m. to 4:00 p. m. respectively, are given in columns 2, 3 and 4 of the table.

| Hour. | Slant.<br>Deg. | Shadow-<br>Length.<br>Min.-Sec. | 48.8<br>I=—<br>Length. |
|-------|----------------|---------------------------------|------------------------|
| 7:00  | 4.7            | 48.8                            | 1.00                   |
| 8:00  | 14.8           | 15.9                            | 3.12                   |
| 9:00  | 24.0           | 9.8                             | 5.14                   |
| 10:00 | 30.8           | 7.8                             | 6.47                   |
| 11:00 | 34.3           | 7.1                             | 7.02                   |
| 12:00 | 34.9           | 7.0                             | 7.12                   |
| 1:00  | 32.4           | 7.5                             | 6.67                   |
| 2:00  | 26.6           | 8.9                             | 5.57                   |
| 3:00  | 17.8           | 13.1                            | 3.81                   |
| 4:00  | 8.0            | 28.7                            | 1.75                   |

The values of the slant from hour to hour are laid off to scale on the system of parallel and equally-spaced verticals shown in the drawing of Figure 2.

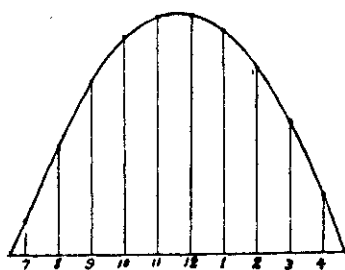


FIG. 2.

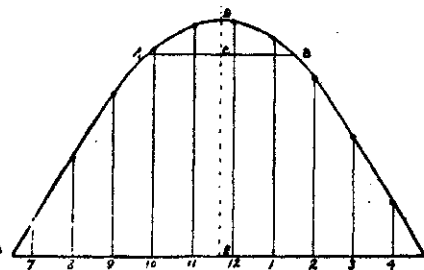


FIG. 3.

Drawing the line,  $AB$ , parallel to the base line of the drawing, bisecting it, and erecting a perpendicular,  $DE$ , at the middle point,  $C$ , the point,  $D$ , where the perpendicular cuts the curve is the noon point. Interpreting the position of the point,  $R$ , in time we find that apparent noon occurred at about 11:40 a. m. on this date. The American Ephemeris gives 11:44. Although this result can hardly be considered accurate enough for a determination of the error of the timepiece, the method at least has the virtue of indicating quite clearly the principles on which such a determination depends. That there is a real difference between sun time and mean time (correct clock time of the place) and that

there is a simple way of getting at this difference experimentally are made pretty clear to the student.

The hourly values of  $l$  (the length) are laid off to scale on a similar system of parallel verticals in Figure 3. The curves visualize the fact that at apparent noon both the slant and the intensity of light and heat are greatest. This means, of course, that the direct values of the slant, light- and heat-intensity are greatest at apparent noon. But the intensity of heat is cumulative, while the slant and light-intensity are not.

The study may here profitably shift to the explanation of the well-known fact that the hottest part of the day actually occurs

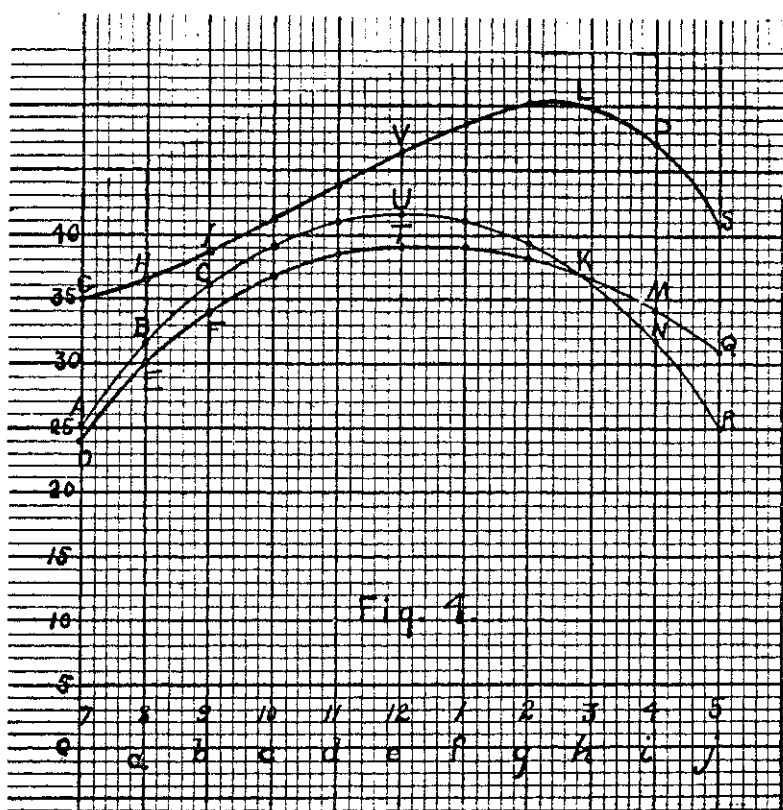


FIG. 4.

not at noon, but at about 2 p. m. The use of the graph may here again be called into requisition to impress upon the class how it comes about that the temperature must continue to rise so long as the income of solar heat is greater than the outgo from the earth's surface, must cease to rise when income and outgo become equal and must begin to fall so soon as the outgo exceeds the income. This is not an easy idea to teach properly and its importance justifies the expenditure of a little time upon it.

In the drawing (Fig. 4) let  $OA$  represent to scale the number of heat-units received by a square unit (say  $1m^2$ ) of the earth's surface from 6 a. m. to 7 a. m.;  $AB$  the number of units received from 7 a. m. to 8 a. m., etc., to  $jR$ . Then the curve  $ABC \dots R$  pictures the hourly receipts of heat from 7 a. m. to 5 p. m.

But heat and light are being simultaneously given off, or radiated, by this same square unit of area. Let  $OD$ ,  $aE$ ,  $bF$ ,  $\dots jQ$ , denote the hourly radiations of heat from 6 a. m. to 7 a. m., 7 a. m. to 8 a. m., etc. Then the curve  $DEFTMQ$  pictures the hourly expenditures of heat by the square unit of surface.

The earth's surface, however, warms or cools by reason of the difference between receipts and expenditures. Suppose, then, at 7 a. m. the square unit in question contains thirty-five units of heat energy, represented to scale by the line  $OG$ . During the hour from 7 to 8 a. m. the surface unit receives according to the diagram 31.7 heat units and radiates off into space 30 heat units, giving an increment equal to 1.7 heat units, making the total content of heat of the square unit now equal to  $35 + 1.7 = 36.7$  heat units. This is represented in the figure by the line  $aH$ . In a similar way by adding the increment  $CF$  to  $aH$  obtain  $bI$  and ultimately the entire curve,  $GHI VLPS$ . This gives the diurnal curve of total heat quantity. This unit of surface may be regarded as typifying any and all the units exposed to the sun's rays. The curve,  $GHI VLPS$ , may then be regarded as picturing the daily heat change for an entire locality.

#### QUESTIONS.

1. When is the hourly income equal to the hourly outgo of heat?

2. When is the difference of income and outgo greatest?
3. When is the income greater than the outgo? Less?
4. When is the total store of heat in the square unit greatest?
5. When does the curve of total heat store rise fastest? Fall fastest?

6. Tell now why the hottest time in the day is not at 12 m.

7. Tell why the curve of total heat continues to rise after the income of heat has begun to fall off.

8. Explain why the hottest time in the year is usually after June 22. Use the curves of Figure 4.

It may be worth while to have the pupil construct the curves from assumed monthly incomes and outgoes of heat furnished by the teacher to clear up this important law. One law well worked out and clearly grasped is worth more to the student than vague general ideas of a dozen. This is remarked for the encouragement of those teachers who are so prone to imagine they can not take time to teach anything well.

My next paper will deal with ways of using common almanac data relating to the moon.

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## A HOME-MADE HIGH FREQUENCY COIL.

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The principles involved in the construction of this coil are not in any way novel, for they have been used by the inventors, Tesla, Thomson and Kinraide, in their high frequency coils. The real advantage of this form of construction is that it is inexpensive, easy to build in the workshop of any good physical laboratory, and in case of a breakdown the fault can be quickly detected and repaired, because of its openness of construction.

The general arrangement of the parts of the coil is shown in Fig. 1, where  $F$  represents the fuses (15 amp.) in the 110-volt alternating current mains,  $S$  the two-pole jackknife switch,  $R$  the adjustable rheostat,  $T$  the step-up transformer,  $P_1$  the primary and  $S_1$  the secondary,  $C$  the condenser,  $G$  the spark-gap,  $H F C$  the high frequency coil, of which  $P_2$  is the primary and