HOW TO OBSERVE AND RECORD THE WEATHER.

BY THALEON BLAKE, C.E.

The weather is always with us. Upon its condition depends our physical comfort, our material welfare, our food supply, our outdoor amusements, our sports, and to a certain extent the prosecution of our business enterprises. Because men are so intimately, so profoundly affected by environment, the study of climate is receiving more and more attention from progressive governments.

Each day wears its appropriate dress, summer or winter; and the observation of this daily individuality of the weather constitutes a major part of the duties of weather observers. The United States Weather Bureau forecasts the weather, issues storm warnings, displays frost, cold wave, and flood signals; receives, tabulates, and distributes meteorological information for the benefit and safeguarding of agriculture, commerce, and navigation. About two hundred regular observing stations are maintained in the United States and the West Indies, each in charge of a trained observer, who telegraphs to Washington the weather conditions from his local office twice a day—8 A. M. and 8 P. M., seventy-fifth meridian time.

On these observations are forecast the weather conditions for the ensuing thirty-six to forty-eight hours. All of these stations have mercurial barometers, thermometers, wind vanes, rain and snow gages, and anemometers. Many of them have in addition, sunshine recorders, barographs, thermographs, that register, automatically and continuously, the changes of the weather. The governments of Mexico, Canada, England, Germany, France, Portugal, and some others, more or less effectively, maintain similar services, so that, by exchange of information, the weather conditions that obtain over North America, North Atlantic Ocean, and West Europe are very thoroughly observed, and forecasts made with dispatch and accuracy.

The art of predicting the most probable condition of the weather for the ensuing twenty-four to forty-eight hours depends on the observations over a considerable area, and on the experienced judgment of the forecasters in predicting conditions likely to follow those at the time of taking the observations.

There seems to be much mystery attached by the general public to the observation and recording of the weather. This supposition is erroneous. The weather itself is seldom complex. At a given hour on any day, it is hot or cold; the sun shines or the sky is overcast; it rains or snows, or there is no precipitation; the air is calm or breezes blow, or there is a hurricane. The weather being reducible to such simple terms, it follows that a comprehensive record of observations need not be abstruse to be valuable. Nor is the observation of the weather by co-operative observers of the Weather Bureau difficult to learn or to take. The great extent of the territory of which it is necessary to have reports, would render impossible any large corps of observers if they all had to be paid. Fortunately, hundreds of people are interested enough to volunteer their services to the government. This enables the Weather Bureau to multiply its observers at little more cost than that of supplying the instruments and the stationery, all of which are lent to responsible and experienced volunteers. The co-operative observers, as a whole, although serving without pecuniary compensation, display much interest and care in their work. Through its principal stations, the Federal government supplies the co-operative observers with thermometers, a shelter in which to house them, and a rain gage. Some may have a larger equipment; but these comprise the customary number.

It is required of co-operative observers that they read the thermometers once a day, at 7 P. M. The temperature is read on thermometers exposed to free air. Two thermometers are necessary to obtain the highest and lowest temperature, named, respectively, the maximum and the minimum thermometers. The minimum thermometer registers the lowest temperature for the past twenty-four hours. It is filled with alcohol, and its registering of the lowest temperature is accomplished by means of a double-headed, pin-like object, called an index, that slides freely in the alcohol within the glass tube. Solely because the index remains in the alcohol, it is enabled to go down and register the lowest temperature of the period since it was last "set." (Fig. 1.)

For instance, if, during the night, the temperature falls from 85 to 50 degrees, the alcohol column descends, of course, toward the bulb. Then the end, or top surface, meets the head of the index, and takes the index down with it. While the index will not suffer the alcohol to pass on down, and leave it in the vacuum above, it will allow the alcohol to flow above it, meanwhile remaining at rest at the lowest point reached by the top of the column of alcohol. It is obvious that because the index will not permit the surface of the alcohol column to flow past it on the way to the bulb, but will lie still when the column of alcohol flows upward with the increase of warmth, the lowest temperature is registered. The maximum thermometer is designed to register the highest temperature of the preceding twenty-four hours. It is filled with mercury, which, owing to a stricture in the tube near the bulb (Fig. 2), can flow freely from the bulb as the temperature rises, but when the temperature falls, it cannot easily flow back. Thus imprisoned above the stricture, it registers whatever degree was the highest attained by the temperature for twenty-four hours.

The words "top" and "bottom" are used advisedly, as the minimum and maximum thermometers are

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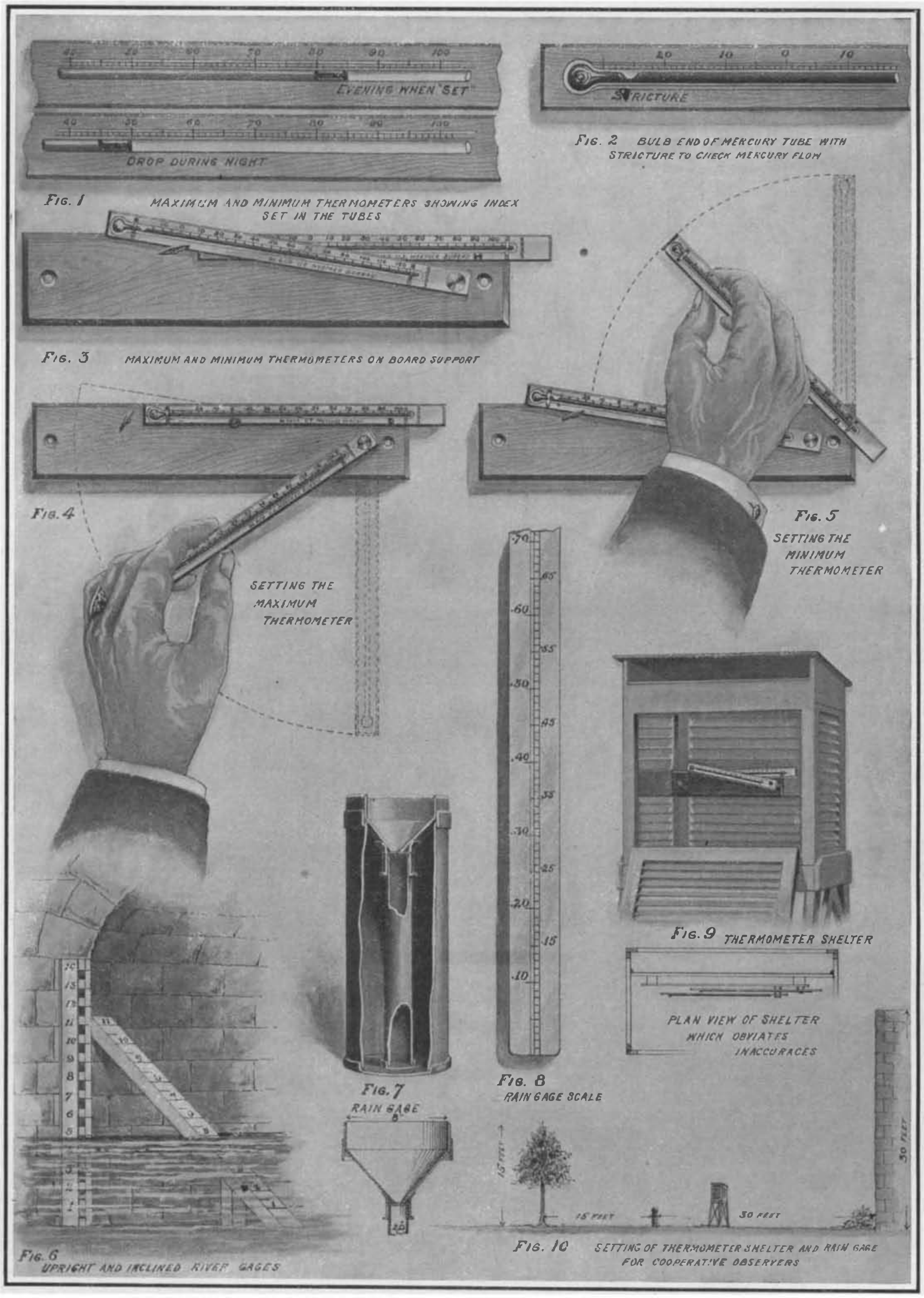

HOW WEATHER DATA ARE COLLECTED FOR THE WEATHER BUREAU BY AMATEUR OBSERVERS.

NEW BOOKS, ETC.

Fundamental Principles of Chemistry. An Introduction to All Textbooks of Chemistry. By Wilhelm Ostwald. Translation by Harry W. Morse. New York: Longmans, Green & Co., 1909. 8vo.; pp. 349.

Prof. Ostwald's name is one to conju with in almost every branch of science and in chemistry particularly. It would be difficullt indeed to mention a chemist who has contributed more to the advancement of his science in our time, or one who occupies a more eminent position as a teacher. In this book Prof. Ostwald has presented with remarkable ingenuity and simplicity the actual fundamental principles of the science of chemistry, their meaning and connection, and stripped them so far as possible of irrelevant additions. The book may be regarded as an attempt to work out chemistry under the form of a rational scientific system without bringing in the properties of individual substances. Hence, it has been necessary to restate elementary principles in a new light, and to bring out many new connections in regions hitherto untouched. That is why this work will be found different in its treatment from any other work on chemistry that has ever been written. The pedagogic value of the preceding can be judged only by the instructor of chemistry. But to anyone familiar at all with chemistry, its merit must be apparent from an impartial consideration of the book.

A Hand Book of Practical Calculation and Application of Reinforced Concrete. Kahn System Standards. Compiled and published by the Engineering Department of the Trussed Concrete Steel Company. 12mo.; 126 pp.

The rapid growth of reinforced concrete construction makes necessary a hand book on design, similar to those in use for the ordinary classes of building material. The object of this hand book is to present to the designer tables and information in such form as to be made immediately available for use in actual designs, and at the same time to have these tables founded on scientific formulæ approved by our best engineering practice. The work as presented deals mainly with the Kahn trussed bar. The Kahn system of reinforced concrete, however, uses in its application several other types of reinforcement, including rib metal, hy-rib, cup bars, column hooping, rib lath, and rib studs.

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mounted very nearly horizontally. These two instruments are usually supported as they appear in Fig. 3.

The minimum is read and then "set" by raising it gently until the index slides to the surface of the alcohol (Fig. 5). The maximum must be lowered to a vertical position before it is read (Fig. 4). After this reading is taken and recorded, the thermometer is then "set" by gently swinging it up and down, until that amount of mercury is shaken back into the bulb that represents the difference in temperature between the maximum and the present, if any. When no more mercury can be returned to the bulb, the thermometer is allowed to hang vertically, and a second reading is taken. The mercury now gives the temperature at the time of reading; and this reading is recorded as "set maximum." In other words, the maximum thermometer serves in place of two thermometers. First, it records the highest temperatures during the twenty-four hours; and secondly, when it is set, it gives the temperature at 7 P. M.—the time of reading.

Exposure.—The marked variation between the readings obtained from thermometers owned by private persons and Weather Bureau thermometers is due much more frequently to the difference in the manner of exposing them than to difference in quality, accuracy, or cost price. Thermometers exposed against buildings, on verandas, in windows, cannot often be trusted to give even approximately the true temperature of the atmosphere. For the air is not a stationary body, but is a continuously intertwisting, expanding, and contracting gas perpetually seeking an equilibrium, which is seldom even momentarily gained, than it is instantly lost. All gross inaccuracies attending exposure of thermometers are overcome by the shelter adopted by the Weather Bureau and provided to all observers (Fig. 9).

The outside dimensions are 42 inches long by 36 inches wide by 36 inches least height, and a second roof, 6 inches above, has two ends open. The air has free access to the interior, for the four sides of the shelter are louvered; that is, composed of shutters. These shutters overlap, and have a pitch which enables them to shed water, and intercept also the rays of the sun, even when level at sunrise or sunset.

Shelters ought to be placed in a large open space, or upon a house top or other high building, where the circulation of the air is unimpeded. Correct temperatures are recorded only when the air flows freely round the shelter as well as through it. When the shelter cannot be situated in an open area, it may be set up on the north side of a building, with a space not less than four inches intervening.

Sunshine does not give the average temperature of the air, but the highest; and so a thermometer, hung in the sun, falsifies or greatly exaggerates. If the temperature is 87, a thermometer in the sun will run up to 100 or more. The confiding observer, suddenly aware how hot it apparently is, grows faint from the imaginary heat, runs for a fan, and rapidly raises his bodily temperature by his vigorous gesticulations trying to cool himself.

Instruments that measure the depth of the fall of rain are neither well known by sight, nor is the method by which they record the rainfall very familiar.

Fig. 7 shows the essential parts of a rain gage, which are a receiver, a measuring tube, and an overflow. The rain is caught by the receiver, the bottom of which is funnel shaped, and falls into the measuring tube. Should the amount that falls be excessive, and more than fill the measuring tube, the excess overflows into the outer cylinder. The rain gage is designed to catch the precipitation of rain, and to facilitate the reading of the amount by mechanically magnifying the quantity. The diameter of a Weather Bureau rain gage receiver at the top is 8 inches; the diameter of the measuring tube is 2.53 inches. In consequence of this difference in area, the water in the measuring tube stands ten times deeper than if spread over the area of the receiver; so that a rainfall of one inch in the receiver stands ten inches in the measuring tube. The scale by which the water is measured is graduated in hundredths of an inch; but that inch on the scale is really ten inches long (Fig. 8).

In the normal temperate climate, there are only a few rains in a year when a reading of one inch is observed. A fall of rain amounting to two inches is uncommon; a precipitation recording three or more inches is the exceptional record of a decade or two. Some rains, attended by strong wind, vivid lightning, and apparently heavy downpouring of sheety rain, give a reading as low as twenty-five to sixty or seventy hundredths of an inch; while other rains, not so accompanied by electric phenomena and aerial disturbances, occasionally give a reading of an inch or more. Only an experienced observer is competent to make a fairly close guess of the amount of precipitation; and at best his guess is subject to the errors that so commonly invalidate all suppositions.

Snowfall is caught in the large cylin-

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der by removing the funnel and tube. It is measured by first melting the snow, then pouring the water into the measuring tube, and ascertaining the quantity exactly as for rain. The measuring tube may be filled to the brim with warm water, and this poured on the snow, which will soon melt. The measuring tube is filled once, and then emptied; the remainder of the fluid represents the precipitation from the snowfall. A third way of arriving at the snowfall is to cut a section of snow by turning the receiver down over it where the snow is level and not blown away nor drifted by wind. The section is then carefully lifted by a small shovel or paddle board, melted, and measured. To learn approximately the depth of water in a snowfall, one-tenth of the thickness of the layer of snow is taken, ten inches of snow being estimated to contain one inch of water; but this gives too little if snow is wet.

EXPOSURE OF RAIN GAGE.—It will not do to set up a rain gage anywhere and expect to get exact measurements of precipitation, for the rainfall varies as much as thirty per cent below the normal according to location, owing to the action of wind currents, to the intervention of buildings, trees, or fences unduly near the gage. A roof must be at least sixty feet square, and level, ere the wind action on the side walls of a building is eliminated from influencing the rain gage in the center.

Wind brakes are desirable around an instrument; the rule being that obstructions must be removed a distance equal to their height. For this reason, a fence surrounding a rain gage, four feet high and four feet away, will favorably overcome the wind, so that on a large open space more water will be caught by the receiver. For it is to be understood that the fluctuations of amounts caught between two rain gages near each other is to be ascribed to the wind. Consequently, rain gages protected at a suitable distance from the violence of the wind by bushes, fences, trees, or buildings catch more water than unprotected rain gages. This may be attributed partly to side currents whirling near the ground, and partly to the splashing of the drops of rain if they strike the gage through these intertwisting ground currents (Fig. 10).

RIVER GAGES.—A river gage is a scale by which the height of water in a stream may be measured; and the stage of water, whether low or high, may be observed and recorded. The Weather Bureau endeavors to get reliable data of all streams that affect inland navigation. It so happens that it is sometimes important to receive reports of the condition of the upper reaches of certain tributaries that are themselves unnavigable, but whose flooding may seriously imperil towns below, and materially swell the high water of the navigable rivers into which they empty.

A river gage can be a simple contrivance, and answer all practical purposes for creeks and small rivers. A graduated board extending below the lowest known level, fastened against a bridge abutment, is unexcelled, if it be convenient to read it at all times. The stone facing of an abutment itself may be smoothed and graduated, and be made to answer almost as well as an elaborate device (Fig. 6).

Strips of brass or of lead, securely inset or marks burned in, will do for graduations. The "feet" should be plainly numbered, lest in reading the gage, when the water is very high, a mistake is made. Great care must be exercised to graduate the sloping timbers of this style of gage; for which nothing less than an engineer's level is sufficiently accurate for governmental requirements. The illustration explains how this may be done with a carpenter's level.

The book in which the observations are written is called the "Meteorological Record." The pages of this record are ruled for date, maximum, minimum, range, set maximum, precipitation, prevailing direc-

(*Concluded on page 420.*)

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tion of the wind, character of the day, and remarks.

Opposite the date is set down the reading of the highest and lowest temperatures; the difference is placed in the range column; the set maximum, as explained above, is the temperature at the time of reading. The time of beginning and the time of ending, with the amount of precipitation, is next entered in the record. The prevailing direction of the

METEOROLOGICAL RECORD,
May, 1905 (at Sidney, Ohio).

Date.	Set Max. 7 P. M.	Maximum.	Minimum.	Range.	Precipitation. Time Beginning	Precipitation. Time Ending	Amount.	Wind.	Char. Day.	Remarks.
1	53	59	35	24	....	....	....	S.	Clear.	....
2	73	83	46	37	....	....	....	S.	Clear.	....
3	75	82	60	22	....	....	....	S.	Clear.	....
4	73	87	62	25	5:40 P. M.	....	0.07	S.	Clear.	....
5	....	....	....	....	D. N.*	7:25 A. M.	0.13	S. W.	Cloudy.	....

* During night. (Copy of Original.)

wind is that direction from which the wind blows the most hours of the twenty-four. The character of the day refers to the sky, whether it is cloudy, partly cloudy, or clear. A sky of 70 per cent freedom, or more, from clouds is said to be "clear"; 50 to 60 per cent without clouds, is called "partly cloudy"; none to 20 per cent without clouds is accounted "cloudy." In the column for remarks may be entered notes descriptive of unusual phenomena, such as severe storms, meteors, killing frosts, remarkable depths of snow, floods in the streams of the vicinity, aurora borealis, deaths by lightning. To make the record valuable by the uniformity of its keeping, it is highly important that the readings be taken at the same hour each day, preferably at 7 P. M., seventy-fifth meridian time. A column for the water gage may be added, if the levels of a stream are to be observed.

TESTING THE MAN-ENGINE.

(Continued from page 413.)

is gaged by another attachment electrically joined to this clock. At the height of the subject's shoulder are arranged, upon a bar, two small hinged uprights. His hand is placed against one of these little posts and he is told to move it as quickly as possible in the direction of the other and to knock both of them down in the least possible time. The clock measures the time interval between the fall of the two uprights, and thus it is possible to time the swiftest movement of the arm in passing through a yard or foot of space. Men are found to be twice as rapid in this movement as women; Indians much slower than whites; negroes more constant than whites in rate of movement.

Another ingenious man-engine gage is a cylinder revolved by clockwork and covered with paper against which rests a marking point moved by air pressure exerted through a tube connecting with any number of attachments. This apparatus is used largely in comparing the workings of the body while under normal conditions and during hard thinking or strong emotion, or after great intellectual or physical effort. Thus when an

(Continued on page 421.)