rapidity is attained, after which little further change occurs.

An interesting experiment may be made with these machines, which illustrates a well-known dynamical principle, by turning the machine at a steady rate, with the wires for transmitting the current disconnected, and observing the great additional force required to maintain the motion on connecting the wires.

The machine may be converted into an electro-magnetic one by transmitting the current from a voltaic pile through the helices of the iron ring, which will then rotate upon its axis. If the current be supplied by another magneto-electric machine, the same result will be produced, and we shall thus have mechanical force, after assuming the form of current electricity, reappearing, but with some loss, in the form of mechanical force. In an experiment on the large scale described by M. Breguet, the loss amounted only to thirty per cent. If during this experiment the machine which supplies the current has its motion reversed, the other machine will soon come to rest, and afterwards begin to turn in the opposite direction. The intensity of the current, M. Breguet remarks, augments with the velocity of the rotation, the electromotive force having been proved by experiment to be proportional to the velocity. At first view it might appear that the resistance would remain constant; but as the intensity is found not to be proportional to the velocity of an invariable circuit, we are led to the conclusion that the resistance of the machine is not constant. This important point has been established by M. Sabine, but the details of his experiments have not been published. The increase of resistance is, however, so small, that a machine which gives with a velocity of 100 turns per minute a current equal to that of one small Bunsen's element, will give with a double velocity a current equal to two such elements a little larger, and with a quadruple velocity a current equal to four still larger elements of Bunsen. It is certain that this increase of electromotive force cannot be indefinite, but must tend towards a limit; but this limit does not appear to have been reached even with a velocity of 3,000 turns per minute.

(*To be continued.*)

ON THE TEMPERATURE OF THE HUMAN BODY DURING MOUNTAIN-CLIMBING

IN the year 1869 both Dr. Wm. Marcet, of Nice,* and Dr. Lortet, of Lyons,† published the results of thermometric experiments prosecuted by themselves on themselves during the ascent of Mont Blanc. Both physiologists discovered that during the act of ascent, if it were rapid and prolonged for any considerable time, the temperature of the body fell considerably, as much as 3·6° F. in the case of the English, and even 8·6° F. of the French observer. The temperature was taken in the mouth, and read off by means of a small reflector attached to the thermometer, which is a much more satisfactory manner of recording reducing temperatures than the employment of maximum registering instruments. Dr. Marcet tells us that in order to assure himself that the cooling of the body during the ascent was really due to the muscular effort, and not to the effect of the rarefaction of the air, he made one ascent (from Cormayeur to the plateau of Mont-Frety, about 2,440 yards high) partly on mule-back. After having gone two-thirds the distance, his temperature was 97·5° F., when, leaving the mule, he performed the rest of the journey on foot as quickly as possible. Just before arriving at the end, his temperature was not above 95° F., or 2·5° below what it was thirty-five minutes before, at the lower level. Another peculiarity observed by this author is that the body-temperature, after having diminished during an ascending walk, rapidly rose again upon rest being taken, or on the speed being reduced.

All these unexpected results have, from the absence of fresh facts to throw light upon them, been but little discussed. It has been asked whether the above-described fall of temperature depends on the transformation of the energy of muscular action into work instead of, as usual, into heat in the body. The answer to this question is, however, not so easy as it might at first sight appear. If the exalted temperature of warm-blooded animals in a state of rest is the index of the amount of internal work done by the heart and the respiratory muscles, then extra muscular work will produce a proportionately greater rise of body-temperature, as it is employed in doing less external work, and the reverse; from which consideration it is rendered theoretically probable that the rise in temperature attending a rapid ascent of an incline would be much less considerable than that accompanying a similar effort which is attended by no external effect. In fact, the temperature of an individual in the act of throwing oranges forcibly away in all directions should be scarcely above the normal, whilst if he continually throws one up, again catching it, his temperature should rise considerably. In the one case the muscular effort is employed in heating the ground against which the moving oranges come in contact whilst being brought to rest; in the other case the energy lost to the body in the upward projection of the mass is regained in the form of heat when the muscles of the limbs resist its downward movement in catching it.

At this stage of the inquiry the elaborate investigations of Prof. Forel, of Lausanne,* prosecuted with indefatigable industry during the last four years, form an important addition to the literature of the subject. This physiologist, in a most painstaking and thorough manner, has investigated the whole problem, together with all the minor details associated with it: the results he has arrived at have consequently a wider interest than the simple solution of the question which originally led to their being commenced.

In his earlier series of experiments, Dr. Forel, whilst staying at the Rhone Glacier, at Zermatt and at the Lake of Geneva, ascended the Grimsel, the Riffel, and to Chigney, as well as to other neighbouring heights, in the end arriving at the following conclusions:—firstly, that the method of measuring the body-temperature in the mouth is not sufficiently precise for the study of the influence of muscular exercise on the general temperature of the body; and, secondly, that the act of ascending normally produced an *elevation* of the temperature of the body to the extent of several tenths of a degree, which diminishes during the subsequent repose, in tending to regain the normal standard.

These results, obtained in 1871, being directly at variance with those of Doctors Marcet and Lortet, Dr. Forel repeated his experiments with greater precision during the years 1873 and 1874. He commenced by determining the relative values of the different regions of the body in which it is possible to employ the thermometer for the estimation of the general temperature. More than a hundred observations in the floor of the mouth led him to reject that position for the thermometer, chiefly because it is next to impossible, during muscular exercise, to retain the mouth closed for any considerable time in a cold, dry, rarefied air. The palm of the hand, the arm-pit, and the external auditory meatus were rejected as being even less advantageous. The rectum was the last resource, and its advantages were found to be so great that all the most important results, to be mentioned directly, were arrived at from temperatures obtained in that situation.

The author commenced by forming a curve which repre-

* "Archives des Sciences Physiques et Naturelles." 5e serie, t. xxxvi. p. 247. (Geneva.

† "Recherches Physiologiques sur le Climat des Montagnes" (Paris.)

* "Expériences sur la Température du corps Humain dans l'acte de l'ascension sur les Montagnes." (Geneva and Bale, 1871 and 1874.)

sents the average temperature of his own body at the different hours of the day, in order that he might eliminate this factor as a disturbing cause in his special observations. The curve represents an elevation of the temperature between the hours of 3 and 9 A.M., and a fall between 9 P.M. and 2 A.M., with an elevated temperature during the day, the undulations of which are far from constant and are difficult to characterise. In employing these results practically, Dr. Forel has introduced a method of turning them to account, which is as useful as it is precise and ingenious. In any special experiment, calling t the temperature, and T the normal temperature at the time of observation as found from the tabulated curve, then

$$t - T = t'$$

t' being the difference between the observed temperature and that which, under ordinary circumstances, it would be, either above or below it. As examples, we will take two given by the author :—

At 12 o'clock, noon, $T = 99{\cdot}09°$ F. On one particular occasion t was found to be 99·5° F., and therefore

$$t - T = t' = +0{\cdot}41° \text{ F.}$$

On a second occasion, at the same time of day, the temperature observed was 98·78° F., from which it is evident that

$$t' = -0{\cdot}31.$$

By the employment of this very simple means, therefore, the complications dependent on the time of day at which an observation is made may be immediately eliminated; all comparisons being between the different values of t', and not of t. Whether the assumption that the daily curve of body-temperature-change depends on the time of the day at which the observation is made, and on the time only, is a question into which the author does not enter, notwithstanding that such is the case has been by no means proved.

Turning now to the results arrived at from the investigation, the position in which the subject was left by Marcet and Lortet may be thus summarised :—

1. The temperature of the body, as a rule, falls during the act of ascending an incline.

2. During the time of the "mountain sickness," which so frequently accompanies the ascent of lofty heights, the body-temperature falls in a very marked manner.

Dr. Forel's earlier experiments, conducted in 1871, in which the thermometer was retained in the mouth, as was done by Marcet and Lortet, being directly opposite in their tendency, led him to commence the whole subject in 1872, as he remarks *ab ovo*, under his improved conditions.

As to the effect of an uncomplicated ascent, two instances are given in full, in both of which a considerable *rise* in temperature accompanied a rapid ascent of about an hour's duration. In one of these, at the end of the journey, the thermometer registered 102·5° F., whereas it was slightly below 100° F. on starting.

In a second series, three illustrations are given of the effect of well-marked fatigue, just short of exhaustion. The following are the deductions drawn from them :—

1. Even in conditions of great fatigue, the human body rises in temperature upon the muscular effort of ascending a height.

2. It is impossible for the author to determine if the elevation of animal heat due to the movement of ascension diminishes in proportion to the increase of the muscular fatigue.

Next as to the influence of an empty stomach on the temperature curve; and it must be noted, with regard to this point, that both Marcet and Lortet have stated that the fall in temperature accompanying an ascent is more marked during a fast than shortly after a meal. On himself, Dr. Forel, however, again proves that a fast of twelve or even twenty-four hours is no obstacle whatever to the rise of temperature which attends the muscular effort of ascending a hill.

By collecting and comparing the temperature-curves produced in ascending and descending inclines, the author is enabled to verify the theoretical necessity that the body-temperature is raised more by a descent than by an ascent. From twenty-one experiments, the average rise in temperature attending the act of ascending is found to be 2·412° F., whereas the mean of seven descents is found to be 2·772° F. The difference, 0·36° F., is small, it is true. If this fact is reliable, we find that a certain amount of heat is transformed into mechanical work during the act of ascent, a certain quantity being returned to the organism from without, under the opposite condition.

There are several minor points which Dr. Forel discusses in a particularly instructive manner, amongst which are the time of cooling after muscular exertion, the effect on the pulse and respiration of mountain climbing, and the cause of mountain sickness. He terminates his very interesting observations by the account of an ascent of Mont Rosa in July 1873 (15,217 feet), in which, notwithstanding that he suffered from mountain sickness, the body-temperature never showed any tendency to fall throughout, and was 101·5° F. on his reaching the highest point.

From this summary of Dr. Forel's results, when taken in connection with those of Dr. Allbutt,* it is evident that the temperature-fall observed by Drs. Marcet and Lortet during mountain climbing requires re-verification, and cannot be accepted as a physiological fact until a fallacy has been shown to exist in the method of investigation adopted by the Swiss experimenter. A. H. G.

NOTES

At Cairo, on the 2nd inst., the inaugural meeting took place of the Société Khédivale de Geographie, under the presidency of the eminent traveller Dr. Schweinfurth and the patronage of H.H. the Khedive, who has shown special favour to the young society, having placed at its disposal a handsome suite of apartments furnished in suitable style, and also presented a valuable library, besides subscribing 400*l.* a year to the funds. This cannot but be gratifying to the friends of science and progress, and is a hopeful sign for the future of Egypt and of the extensive region from which it claims allegiance. Let us hope that like results will follow the intercourse between this country and the Sovereign of Zanzibar. With these two African potentates on the side of progress, the advantages to knowledge, as well as to Africa, could not but be great. At all events, under the powerful patronage of the Khedive, this Egyptian Geographical Society is bound to make valuable contributions to our knowledge of North Africa. Dr. Schweinfurth, in his inaugural address, which was characterised by great fervour, spoke of the domain and progress of geography. "It has become," he said, "an immense domain, the meeting-place of all branches of human science. The geography of the present does not aim at merely describing the external form of the earth, the vesture which it has assumed; it seeks to show the chain of hidden causes of which this form is the expression." He then spoke of Africa and the great interest attaching to it, and especially to the Nile, the sources of which he believes contain the key to all the mysteries of Africa. Dr. Schweinfurth then referred to the history of Egypt and its progress under its present ruler, by whose special desire the Society has been organised. The motto of the Society, he said, should be *Nusquam otiosus*, and its duty *Centraliser et encourager*. After pointing out to those who take a "utilitarian" view of science, that all the comforts and commodities of modern life are due to researches which, though purely theoretical in their origin, have yielded magnificent practical results, Dr. Schweinfurth indicated the benefits to be gained from the increase of geographical know-

* *Journal of Anatomy and Physiology*, vol. xi. p. 106.