ON THE MINUTE MEASUREMENTS OF MODERN SCIENCE.

By ALFRED M. MATER.

Article III.

2. On the method of measuring by means of the micrometer screw furnished with the contact level.

The Contact Level is the name given to a spirit level, which is so applied to a micrometer screw, that when the bubble is in the middle of the level we have the screw in the position which is taken for its contact with the body to be measured. The manner in which this application of the level is made may be clearly explained by aid of the accompanying drawing, Fig. 5.

In a plate of brass, P, is cut a slot at its end, A, so that a stout, square rod C can fit loosely into this slot. Two screws—one of them shown at A—enter the sides of the plate P, and traversing it, their points enter conical holes in the rod C. By this mechanism the plate P is hinged on the points of the screws, at A, to the stout rod C, so that when the screw D is rotated the plate P revolves around A as an axis.

A level L is securely attached to the upper surface of the plate P, and to the same plate P is fastened the index I, carrying a scale of equal parts; each of whose divisions equals the pitch of the screw. At the same time the portion of the pitch of the screw is shown by the division on the screw drum D, which is cut by the edge of the index I.

To illustrate the manner of using this apparatus, we will suppose that we wish to compare a carefully constructed yard or foot measure with another standard yard or foot measure, which has been furnished us by the Government Bureau of Weights and Measures. The standard measure, or its carefully made copy, is placed in Vs (not shown in the figure), so that it takes a vertical position. The screw, S, is now slowly turned till the bubble comes into the middle of the level L. The number of the revolution and the fraction of the revolution of the screw are taken from the index I and from the drum D. The standard measure is now removed from the apparatus and the yard or foot, whose error we wish to ascertain, is placed in the same position as that formerly occupied by the standard. If the bubble now occupies the center of the level, then the two measures are of the same length; or, more correctly speaking, they are so nearly of the same length that they do not differ by the smallest length that can be shown by the motion of the bubble of the level. If, however, as is generally the case, the bubble does not come to the center of the level, when the standard is replaced by the measure, then it is brought there by rotating the drum D. If to bring the bubble to the center of the level, we had to move the screw downwards, then the scale is shorter than the standard. If we had to move the screw upwards, then the scale is longer than the standard. The error of the measure is obtained by subtracting the reading given by the screw when the measure was in the apparatus from the reading given when the standard measure was in the apparatus (the bubble of course being in the center of the level in both cases), and by multiplying the remainder by the pitch of the screw.

The reader, of course, understands that in all of these comparisons the temperature of the apparatus, of the standard and of the scale, is the same, and also that during these measures the temperature remains constant.

The degree of precision of a micrometer screw furnished with a contact level depends on the delicacy of the level. With an instrument similar to the one here described, with a level about as sensitive as can well be used for such purposes, and with a micrometer screw of a pitch of $\frac{1}{100}$ th of an inch, I obtained the following series of readings on the drum of the screw for nine successive level contacts of the screw on the end of a stout brass rod:

No.	Measurement.	Dif. betw. mean and measures in fractions of rotation of screw.	Dif. betw. mean and measures in fractions of an inch.
1.	6.50	+ .234	.0000234
2.	6.25	- .016	.0000016
3.	6.00	- .266	.0000266
4.	6.10	- .166	.0000166
5.	6.40	+ .134	.0000134
6.	6.30	+ .034	.0000034
7.	6.50	+ .234	.0000234
8.	6.40	+ .134	.0000134
9.	6.00	- .266	.0000266

Mean = 6.266

The drum of the screw is divided into 100 equal parts; hence, each of these parts equals the $\frac{1}{100}$ th of an inch. The greatest range in the readings of the drum, as shown in column 2, equals .5 or $\frac{1}{2}$ of a division. This range is there-

fore equal to $\frac{1}{200}$ th of an inch. In the third column I have placed the differences between the mean of all the measures and the mean of each successive measure expressed in fractions of an inch. The greatest departure of any one of these differences from the mean of all of the measures is $\frac{1}{10000}$ th of an inch, or, what is the same, the $\frac{1}{10000}$ th of an inch. As this is the extent of the greatest departure of a measure from the mean of them all, and as the greatest range among the separate measures is $\frac{1}{200}$ th of an inch, we feel sure that the mean of nine measures will give us the true measure to at least the $\frac{1}{10000}$ th of an inch.

3. On the method of electric-contact applied to measurements with the micrometer screw.

With the aid of the accompanying drawing, Fig. 6, I will describe the method of obtaining the contacts of a micrometer screw by the aid of a current of electricity. In this method we take as the position of contact that distance of the end of the screw from the surface of the body to be measured, that will just allow a current of electricity to pass between these surfaces. It matters not if this passage of electric current really takes place before the screw touches the body we are measuring; all that is essential is that the distance at which this passage of electricity takes place shall be exactly the same in all of our measures on the body. If the latter condition can be obtained, then the differences between two successive measures will give us the distance we wish to measure. Thus, suppose it be required to measure the increase in length of a metallic rod, when its temperature is increased by a known number of degrees of the thermometer. By appropriate means, which we have recently devised, and which will be described in a future article, the rod can be entirely surrounded by ice or by a current of steam, and yet its ends can be exposed so that the abutting point P, and the end S of the micrometer screw, can be brought in contact with the ends of the rod R R. The end A of the rod is brought into contact with the abutting point P by means of springs, which are not shown in the drawing, but which pull the rod R against the abutting point P, with a pressure which is the same in successive measures. Also, the weight of the rod is partly supported by two springs which reach down from supports above and take hold of the rod at distances from its ends equal to one-fourth of its length. We will suppose that the rod has been cooled down to the temperature of 32° Fahr., by having been immersed for several hours in melting ice. The rod surrounded with ice is now placed in the apparatus, and the springs are attached to the rod to bring it against the abutting point P. The screw S is now slowly rotated and its end gradually approaches the surface E of the rod. At a certain moment the screw S touches the end surface E of the rod, or, at least, it comes so near, that an electric current passes between the screw and the rod. This electric current is generated in the battery B, and thence passes to the block N; then through the screw S and the rod R to the electro-magnet M. This magnet then attracts the iron lever H, and thus brings the hammer at its end to strike the bell G, and to apprise the experimenter that the micrometer screw is in contact with the end of the rod. The reading is now taken from the scale of the index I, and from the drum D of the screw. Steam is now passed around the rod, and after it has ceased to lengthen from the increase of its temperature, we are sure that the rod has the same temperature as that of steam; in other words, is heated to 212° Fahr., or 100° C. The screw is again slowly approached to the rod till the moment when the electric current passes and sounds the bell. The rotation of the screw, at this signal, is stopped, the readings of the index and drum are again taken, and the difference between this reading and the previous one, when

the rod was at the temperature of melting ice or 32° Fahr., gives the increase in length of the rod when it is heated through 180° Fahr. or 100° C. From this measure is readily determined what fraction of the length of a rod, of the material of the one experimented on, expands by having its temperature increased one degree of the thermometer.

The precision of this method of measurement depends upon the following conditions: First, the battery should furnish a constant strength of current and also a weak current; secondly, the electro-magnet should be formed of a short and thick wire; thirdly, the rotation of the drum of the screw should be made so slowly that only a very slight error is produced by the delay in stopping the rotation of the screw at the moment the electric current passes between it and the rod. Indeed, the chief error in the method consists in the difficulty of ceasing to revolve the screw at the very moment that the bell sounds. It takes some time for the signal thus received by the ear to be interpreted by the brain, and thence, for this order to be sent to the hand from head-quarters, stop turning that screw!

This order, no doubt, is always sent from the brain with the same velocity—with a speed, according to Helmholtz, of about 95 feet a second—but the hand is not able to turn the screw always with the same velocity of rotation, hence the screw is rotated, in successive measures, through a greater or less fraction of a turn, after the order to stop moving it has been received.

The writer has, to-day, made a series of measures with an apparatus similar to the one just described, and he has found that with a screw of the pitch of $\frac{1}{100}$ th of an inch, provided with a drum divided into 200 equal parts, that the greatest difference between the measures amounted to only the $\frac{1}{100}$ th of a division on the drum, or, in other words, to the $\frac{1}{10000}$ th of an inch.

MONSTER BAROMETER.

A large aneroid barometer has been placed in the most prominent part of the Paris Halles for the use of the country people who come daily to sell their garden produce. The dial is about 5 feet in diameter, and is lighted at night.

THE SENSATION OF SOUND.

At a recent meeting of the Vienna Academy a paper was communicated by Dr. Isidor Hein "On the Relations between Perceptions of Touch and of Hearing." His conclusions are these:—1. The sound produced by striking a solid body is always accompanied by a sensation of touch, which, like the sound, differs according to the nature of the body. If the sound is different in different parts of a body, there goes along with the variation of the sound, a variation in the touch-sensation; and if the surface be divided into several sections according to differences in sound, a congruent division may be made on the basis of touch. 2. On bringing a struck body towards a reflecting wall, the sound and touch-perceptions show similar variations. 3. To the touch-perception in question correspond vibratory motions of the exterior body, produced even with the weakest striking, whereas sound only begins to be perceived with impacts of a certain intensity. 4. The sense of touch is capable of perceiving vibrations and comparing the differences of these. It brings hereby to consciousness, a special quality of touch-sensation, which is to be distinguished from sensation of pressure. 5. This distinguishing power of the organ of touch, not sufficiently appreciated hitherto, offers practical medicine a peculiar mode of investigation, which greatly enlarges the doctrine of the physical symptoms of the human organism, and for which the author suggests the (German) name of "Erschutterungs-palpation."—*Nature*.

MAGNETIC ACTION OF ROTATORY CONDUCTORS.

By F. ODSTREIL.

FROM a large number of observations of the magnetic effects, caused by a rotating sphere of zinc upon magnets in the vicinity, the author finds that considerable deviations are caused as long as the axis of the sphere does not lie in the direction of the terrestrial magnetism. The law regulating the distribution of magnetic force according to the inclination of the axis has been fully defined. As these induced currents in a rotatory sphere are due to terrestrial magnetism, the opinion of the author is strengthened that the periodically recurring deviations of the needle are possibly due to solar and lunar magnetism.

THE METRIC SYSTEM.

At a recent meeting of the Boston Society of Civil Engineers, the committee on the Metric System made a report, from which we glean the following:

Probably the most important step lately taken is in Sweden, where the Diet has voted to adopt the metric system; its obligatory use to date from 1889. In the United States the Treasury Department has distributed metric standards to the several States, and has introduced the new subsidiary silver coinage of metric weights; the twenty cent piece weighs five grams, as does also the five cent nickel; the weights of the other silver coins are, of course, proportional to their values.

The General Postal Union, ratified by treaty at Berne, October 9, 1874, includes twenty-one nations, and has expressed its rates entirely in the metric system. To this union the United States is a party.

The celebrated American Watch Company, at Waltham, Mass., uses the metric system entirely in its works. The change from English measures was made a few years ago with comparatively little difficulty, by letting the old tools become nearly worn out in the service, and then putting the new ones in their places. The American Watch Tool Company, also of Waltham, has adopted the metric system, and another factory in New Jersey is reported in the same category.

An organization has been formed in Boston city, called the American Metric Bureau. According to Article 2 of its constitution, "it will secure the delivery of addresses; publish articles, circulate books, pamphlets, and charts; distribute scales and measures; introduce the practical teaching of the system in schools; and in all proper ways, as far as the means at its disposal will allow, the Bureau will urge the matter upon the attention of the American people, till they shall join the rest of the world in the exclusive use of the international Decimal Weights and Measures."

The Franklin Institute of the State of Pennsylvania has resolved, "that while we decline to ask for or favor compulsory legislation to enforce a change in our weights and measures at this time, we believe that the adoption of a harmonious system of money, weights and measures, throughout the bounds of mercantile intercourse, is most desirable;" and it has adopted a committee report, signed by Messrs. Coleman Sellers and W. P. Tatham, setting forth "that the objections to the attempt to adopt the meter as a standard unit of lineal measure are overwhelming." The full text of this report may be found in the "Journal of the Franklin Institute" for June, 1876, where is also printed a report by Robert Briggs, the minority of the committee. He protests against the perversions of history and erroneous assumptions as to the consequences of introducing the metric system contained in the majority report, and says, "The universal introduction of the metric system is merely a question of time."

The Report concludes as follows:

After advising so many other people to use the metric weights and measures, we think it would be a graceful thing for the members of this society to do something themselves towards actually adopting them. We think that the place to begin is in writing scales on plans. We recommend, therefore, that upon every plan that has its scale shown by a graduated line indicating feet, miles, etc., a second line should be drawn as a scale of meters. This requires very little additional labor, does not injure the plan for present use, and may enhance its future value, shows what is now the lawful standard of the United States, and how long the meter is as compared with the foot, and it gives the draughtsman his first lesson as to the difficulties that lie in the way of the metric system. This practice can perfectly well be adopted by a very few persons, or even by a single individual, unsupported by the rest of the community.

MICRO-PHOTOGRAPHY.

THE process of micro-photography, adapted so successfully by Colonel Woodward, head of the Army Medical Department of the United States, at Washington, consists in using the heliostat, from whence is thrown a fine pencil of sunlight through the microscope into the camera in a darkened room. Colonel Woodward prepares the finest enlarged micro-photographs ever produced. He has, among other things, by this means clearly demonstrated that any difference between the blood of man, dog, guinea-pig, is microscopically indistinguishable, a fact which has been heretofore contested.