an average about 4000 feet below the effective feeding-ground, or 3000 feet below the snow-line. If the temperature of Bangor were not higher than 32°, then the Snowdonian district would be comparable with one of the Alpine regions where the mountains rise generally from about 1000 to 3000 feet above the snow-line; that is, with such a one as the head of the Maderanerthal, where none of the peaks reach 12,000 feet above the sea. Here the Hüfi Glacier leads to passes rather below 10,000, among peaks of about 11,000 feet in altitude, and it terminates a little above 5000 feet. That is to say, a region, rising roughly from 2000 to 3000 feet above the snow-line, generates a glacier which descends more than 2000 feet below it.

But what change is required to give a Glacial epoch to Switzerland? It is generally agreed that an ice-sheet has enveloped the whole of the lowland region between the Alps and the Jura. Let us assume that, other conditions remaining the same, this could occur if the mean annual temperature of this lowland were reduced to 32°. Its present mean temperature varies somewhat; for instance, it is 45°·86 at St. Gall, 49°·64 at Lausanne. Let us take 47°·5 as an average, which is very nearly the mean temperature of Lucerne.[1] So this lowland requires a fall of 15°·5. We may take the average height of the region as 1500 feet above the sea. If, then, we begin the effective gathering ground at 1000 feet higher, the valley of the Reuss from well below Wasen, and the valley of the Rhone from a little above Brieg, would be buried beneath *névé*. So that probably a fall of 16° would suffice to cover the lowland with an ice-sheet, and possibly bring its margin once more up to the Pierre-à-bot above Neuchâtel; at any rate, a fall of 18° would fully suffice, for then the mean temperature of Geneva would be slightly below 32°.

The line of 41° passes through Scandinavia a little north of Bergen; if, then, the climate of Norway were lowered by the same amount, which also is that suggested for Britain, the temperature at this part of the coast would be 23°, corresponding with the present temperature of Greenland rather south of Godhavn; and probably no part of Norway would then have a higher mean temperature than 26°.

The wants of North America are less rather than greater; though, as geologists affirm, an ice-sheet formerly buried all the region of the Great Lakes and descended at one place some fifty leagues south of the fortieth parallel of latitude. Its boundary was irregular; but if we strike a rough average, it may be taken as approximately corresponding with the present isotherm of 50°. The temperatures, however, in North America fall rather rapidly as we proceed northwards. Montreal is very nearly on the isotherm of 45°, and this passes through the upper part of Lakes Huron and Michigan; that of 39° runs nearly through Quebec and across the middle of Superior, while at Port Arthur, on the same lake, the temperature is only 36°·2. If, then, we assume sufficient precipitation, the maximum fall of temperature required for this North American ice-sheet will be 18°; but less would probably suffice, for the district north of the St. Lawrence would be a favourable gathering ground. This would be brought within the isotherm of 32° by a fall of 12° or at most of 13°.

It seems, then, that if we assume the distribution of temperature in the northern hemisphere to have been nearly the same as at present, we require it to have been lowered, at any rate in the regions named, by about 18° in order to bring back a Glacial epoch. For North Wales a reduction of about 20° might be needed, but if the isotherms ran more nearly east and west, 18° for the Thames Valley might suffice. If we assume the great extension of glaciers in Central and North-Western Europe to be contemporaneous with that in America, we must suppose that these parts of the northern hemisphere had a climate more nearly resembling, but even colder than, that which now prevails in the southern hemisphere. The isotherm of 40° runs a little to the south of Cape Horn; that of 45° passes north of the Straits of Magellan. The latter lie on parallels of latitude corresponding with those of North Wales, but their mean temperature is about 8° lower. If we could restrict ourselves to the British Isles, it would be enough to assume a different distribution of temperature from that which now prevails on the globe, for at the present time, and in the northern hemisphere, the isotherm of 32° twice comes down very nearly to the latitude of London; but it may be doubted whether this alone would account for the great extension of the Alpine glaciers, and the difficulties seem yet greater in the case of North America. Here, where even at present the temperature is rather abnormally low, we have to make a very considerable reduction. But this is too wide a question to discuss at the end of an article in these pages. We seem, however, fairly warranted in concluding that, whatever may have been the cause, a lowering of temperature amounting to 18°, if only the other conditions either remained constant or became more favourable to the accumulation of snow and ice, would suffice to give us back the Glacial epoch.

T. G. Bonney.

[1] St. Gall, 45°·86 F.; Berne, 46°·58; Lucerne, 47°·48; Zurich, 48°·20; Neuchâtel, 48°·74; Geneva, 49°·46; Lausanne, 49°·64. St. Gall and Berne are rather high stations, the one being 2165 feet, the other 1760 feet. The lake of Lucerne is 1437 feet above the sea.

## SURVEYING AND LEVELLING INSTRUMENTS.[1]

This volume fills a gap that has been long felt in consequence of the great dearth of good books treating of instruments used for surveying and levelling. Various books and pamphlets contain descriptions and methods of using instruments of this class, but there is no work in which each instrument is so completely treated as in the present volume.

The author's former work, which has been found to be a most useful help and guide, and is now in its sixth edition, was limited to drawing instruments, among which were those for plan drawing and calculation of areas. The present work is intended to complete the subject by describing theoretically and practically the different instruments that are required and used at the present day. Not only does the author give an excellent and complete description of each typical instrument, but in many cases he shows the methods of use adopted in the field; thus placing before us a good and trustworthy text-book.

Of the instruments treated therein, one is surprised at the many and various kinds that are in use. Among some of the less common instruments we may mention a tacheometer, our illustration (Fig. 1) showing the author's latest pattern of this instrument. As regards its general appearance, it differs very slightly from a theodolite, but, when closely examined, it will be found that the graduation of the arcs and circles is made upon the centesimal system, the circle reading 400 grades, and reading to 0·01 grade by a micrometer or vernier. The compass is of the cylindrical form, and is inside the small telescope placed below the horizontal circle, and is read by a very ingenious method. The telescope is made of a much larger size and of higher power than those generally employed in theodolites. To facilitate calculation, a logarithmic slide-rule forms part of the equipment of this instrument. A very neat and ingenious mining survey transit, the result of various improvements suggested by the author, is illustrated in Fig. 2. It should be found of

[1] "Surveying and Levelling Instruments." By William Ford Stanley. (London: E. and F. N. Spon, 1890.)

the utmost value when used in close working, for the circles are so arranged that they can be very easily read, the horizontal circle being so adjusted that the reading can be taken when the instrument is near the roof of a mine. The telescope has a wide field of view, and on it are

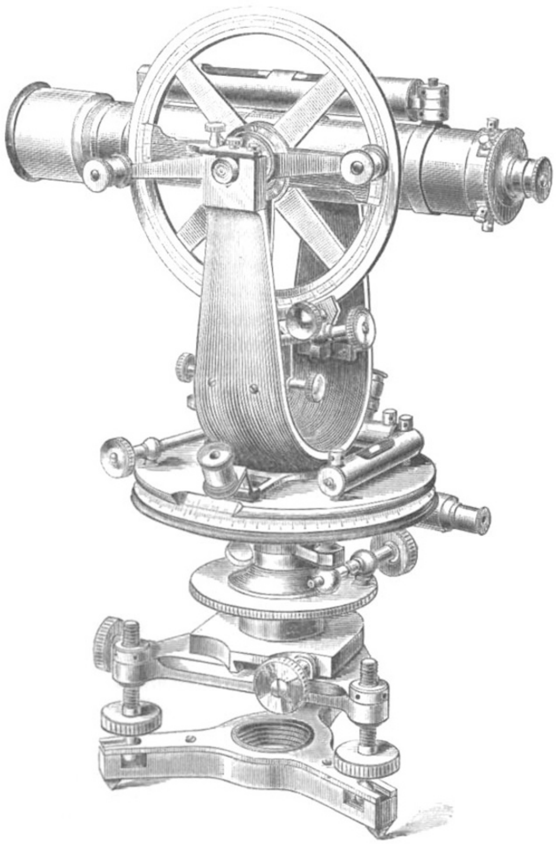

FIG. 1.

placed two pairs of sights made on a new principle for roughly sighting an object or station, or for use in difficult positions.

Another very compact little instrument which has been improved by the author is the box sextant with a continuous arc of 240°.

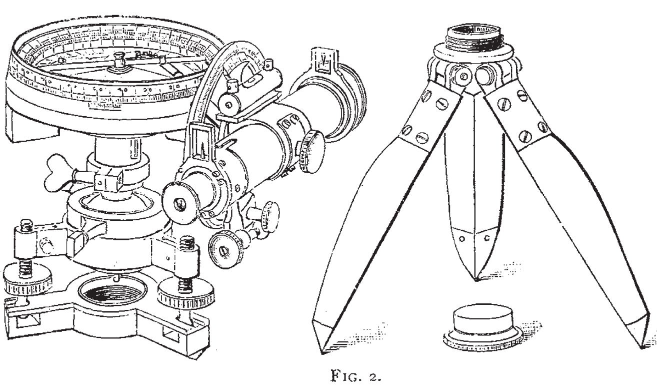

FIG. 2.

Among the miscellaneous instruments described at the end is mentioned a portable saw made of hardened steel plates riveted together in double series, and slack enough to allow the rivets to form joints. This saw "is equal to a 6-foot cross-cut saw, weight complete $2\frac{1}{4}$ pounds, including case, which measures over all $1\frac{3}{4}$ by 4 by 8 inches. Two men with this saw may cut a tree down, 12 inches in diameter, in about 10 minutes."

We need only say in conclusion that the work is deserving of the highest praise, and will be found invaluable to surveyors and others whose work makes it necessary for them to use or study instruments of this kind. For besides laying before the students of surveying or mining the principles and methods of use of each instrument of its class, and also the best tests for assuring the qualities of each, it provides information which will be of much service to skilful instrument makers. W.

## *PROFESSOR SOPHIE KOVALEVSKY.*

THE Swedish papers bring us the sad news of the death of the lady-Professor of Mathematics at the Stockholm University, Mme. Sophie Kovalevsky. She spent her Christmas holidays in the south of France, returned to Stockholm on February 4, and began her course of lectures on the 6th. On the evening of that day she felt ill, and on the 10th she died of an attack of pleurisy. She was born in 1853 at Moscow, and spent her early childhood in a small town of West Russia, where her father, the general of artillery Corvin-Krukowski, was staying at that time; and afterwards on her father's estate in the same part of Russia. She received her first instruction from her father, but it seems that it was her maternal uncle, an engineer of some renown, Schubert, who awakened in her an interest in natural science. She early lost both her mother and her father, and, having ardent sympathy with the movement which was spreading among Russian youth, she applied for, and at last obtained, permission to study at St. Petersburg. The next year—that is, in 1869, when she was but sixteen years old—she was received as a student at the Heidelberg University, and began the study of higher mathematics. About this time, when extremely young, she married Kovalevsky, the well-known Moscow Professor of Palæontology. From 1871 to 1874, she was again in Germany, this time at Berlin, studying mathematics under Weierstrass; and at the age of twenty-one, she received the degree of Doctor of Philosophy at Göttingen. Her husband died in 1883, and the next year, in June, she was offered the chair of higher mathematical analysis at the Stockholm Högskola, on condition that she should lecture during the first year in German, and afterwards in Swedish. This she did, and most successfully too—some of her Swedish pupils already being professors themselves. Her chief mathematical papers were: "On the Theory of Partial Differential Equations" (in *Journal für Mathematik*, 1874, vol. lxxx.): "On the Reduction of a class of Abel's Integrals of the Third Degree into Elliptical Integrals" (in *Acta Mathematica*, 1884, vol. iv.)—both being connected with the researches of Weierstrass; "On the Transmission of Light in a Crystalline Medium" (first in the Swedish *Förhandlingar*, and next in the *Comptes rendus*, 1884, vol. xcviii.), being part of a larger work in which Mme. Kovalevsky shows the means of integrating some partial differential equations which play an important part in optics; and "On a Particular Case of the Problem of Rotation of a Heavy Body around a Fixed Point" (in the *Mémoires* of the Paris Academy: *Savants étrangers*, vol. xxxi., 1888). The third of these works received from the French Academy the Prix Baudin, which was doubled on account of the "quite extraordinary service" rendered to mathematical physics by this work of Sophie Kovalevsky. She was also elected a Corresponding Member of the St. Petersburg Academy of Sciences.

Besides her mathematical work, Sophie Kovalevsky had lately begun to give literary expression to her ideas