that the principal Guyou formulæ may be deduced with little difficulty from the well-known Napier's analogies as follows.

Let us suppose, as before, that in a spherical triangle the three sides a, b, c being given, it is required to determine the angles A, B.

We have

$$\tan\frac{a+b}{2} = \frac{\cos\frac{A-B}{2}\tan\frac{c}{2}}{\cos\frac{A+B}{2}}$$

$$= \frac{\cos\frac{A}{2}\cos\frac{B}{2} + \sin\frac{A}{2}\sin\frac{B}{2}}{\cos\frac{A}{2}\cos\frac{B}{2} - \sin\frac{A}{2}\sin\frac{B}{2}}\tan\frac{c}{2}$$

$$= \frac{1 + \tan\frac{A}{2}\tan\frac{B}{2}}{1 - \tan\frac{A}{2}\tan\frac{B}{2}}\tan\frac{c}{2}.$$

Let

$$\tan\frac{A}{2}\tan\frac{B}{2} = \tan\frac{x}{2} \quad . \; . \; . \; . \; . \; . \; . \quad (1)$$

Then

$$\tan\frac{a+b}{2} = \frac{1 + \tan\frac{x}{2}}{1 - \tan\frac{x}{2}}\tan\frac{c}{2} = \tan\left(45^\circ + \frac{x}{2}\right)\tan\frac{c}{2}.$$

Whence

$$\text{MP}(x) = \text{MP}(90^\circ - c) - \text{MP}(90^\circ - \overline{a+b}) \quad . \; . \quad (2)$$

An equation which determines x.

While from equation (1) it may be deduced that

$$\text{MP}(90^\circ - \text{A}) + \text{MP}(90^\circ - \text{B}) = \text{MP}(90^\circ - x) \quad . \quad (3)$$

Proceeding in the same manner to expand

$$\sin\frac{A+B}{2}, \sin\frac{A-B}{2}$$

in the expression

$$\tan\frac{a-b}{2} = \frac{\sin\frac{A-B}{2}}{\sin\frac{A+B}{2}}\tan\frac{c}{2},$$

and assuming that

$$\tan\frac{B}{2}\cot\frac{A}{2} = \tan\frac{y}{2} \quad . \; . \; . \; . \; . \; . \; . \quad (4)$$

we arrive at the equations

$$\text{MP}(y) = \text{MP}(90^\circ - \overline{a-b}) - \text{MP}(90^\circ - c) \quad . \; . \quad (5)$$

$$\text{MP}(90^\circ - \text{B}) - \text{MP}(90^\circ - \text{A}) = \text{MP}(90^\circ - y) \quad . \quad (6)$$

By adding and subtracting each side of the two equations (3) and (6), we obtain equations which will enable us to determine the values of A and B respectively.

In place of the notation "MP," M. Guyou adopts the Greek letter λ (lambda). Thus, meridional parts for an angle $\theta = \lambda(\theta)$.

He also indicates the meridional parts of the complement of an angle by the symbol Co-λ, so that meridional parts for the angle $(90^\circ - \theta) = \text{Co-}\lambda\,(\theta)$.

And in his excellent collection of tables the values of λ and Co-λ are given for each angle side by side, an arrangement which much facilitates the work of computation.

The ordinary employment of Napier's analogies in practical work is limited to finding the remaining two sides when two angles and the included side are given, or to finding the remaining angles when two sides and the included angle are known. It is a somewhat remarkable extension of their functions to find that they suffice also to furnish satisfactory logarithmic formulæ for solving a triangle where the three sides are the given parts. In a similar manner formulæ may be found which will determine the sides when the three angles are given, so that formulæ of the type which gives $\tan\frac{A}{2}$ in terms of functions of the sides, or $\tan\frac{a}{2}$ in terms of functions of the angles may be dispensed with altogether.

It would be premature at present to hazard a conjecture as to whether the new processes will come into general use in England. In these matters we move slowly. The British mariner does not easily surrender the methods upon which he has been brought up, the practice of which becomes almost automatic with him, and he looks with feelings of doubt, tempered with suspicion, upon any novelties that may be brought to his notice. But some advantages, at least, of a system of rules involving the use of only one table of logarithms must be obvious to all. In the first place, as has been already mentioned, we have that of the greater simplicity in the statement of rules, and the diminished risk of error through the taking out of a logarithm from a wrong column. But even more important than these is the saving of time lost at present in turning over the leaves of tables in hunting for sines and cosines in different parts of a somewhat bulky book. In the table of meridional parts we have but 5400 logarithms, occupying some nine pages of Inman's collection, not more than might be printed on a sheet of cardboard of moderate size, so as to save the turning over of leaves altogether.

These logarithms furnish results correct to the nearest minute of arc, which is the usual limit of accuracy aimed at by the practical navigator.

As the case stands at present, the new system is well thought of in France; it has excited considerable attention in Italy, and has won the approbation of at least one distinguished authority in Spain; so that, perhaps, M. Guyou is not over-sanguine in his expectation that "the table of meridional parts is destined to become sooner or later the universal instrument of computation amongst mariners."

H. B. G.

THE NEW PHYSICAL RESEARCH LABORATORY AT THE SORBONNE.

An interesting account of the new physical laboratory at the Sorbonne recently appeared in *La Nature.*

This laboratory, originally situated in the old Sorbonne, was founded in 1868 by M. Jamin, who was its director until his death in 1886. In 1894 it was transferred to the new Faculty of Sciences, and was reconstructed by the architect M. Nénot. At the present time M. Lippmann, member of the Institute, is the director. Although this change took place in 1894, the work has only recently been carried on in the usual manner.

The new buildings are surrounded by other buildings connected with the Sorbonne, and are therefore away from any disturbances caused by passing vehicles. On the ground floor, after passing an entrance hall with a cloak-room, there is a large room (Fig. 1) two stories high, and measuring 16 metres (about 52 feet) long by 12 metres broad (about 39 feet). Six physicists can work here, provided their work does not require any special conditions with regard to light and isolation. In the middle of the room, and at the corners there are solid stone pillars isolated from the floor; a "comparateur" is attached to the one in the middle. Each of the six places has four jets of gas, two incandescent lamps, one arc lamp, and a water-tap. About two yards above each table there is a joist, thus making it possible to suspend apparatus if necessary; the tables themselves are of slate.

Next to this large room is the sub-director's room and laboratory; then we come to a small chemical laboratory, and finally the machine-room. The latter is built over a vault, and contains two Lenoir gas machines of 16 horse-power each, three dynamos, and a large switchboard, which makes it possible to distribute the current for various uses in the laboratory, such as illumination, experiments and accumulators. Above this room, and accessible by a staircase from it, is the mechanical workshop, well equipped with apparatus and under the direction of two mechanics and an electrician. All the machines are worked by electricity. On the same floor there is an open terrace for the accumulators, which include a battery of the Tudor system used for illuminating purposes (60 elements), and another battery, of the Peyrusson system (80 elements), for experiments. Facing the workshop is a large hall, used as a laboratory by the assistants. This is connected with the workshop by a gallery, which is at present given up to experiments on electric waves. Next to this laboratory there is a terrace and a photographic room, and in the large entrance hall on the first floor are M. Lippmann's private room and laboratory. The latter is divided into three parts, a light and a dark room, and another room for optical researches, with optical benches of slate. The ore-dresser occupies the last room on this floor.

A tower 40 metres (nearly 131 feet) high contains the general staircase, and also leads to the extensions of the upper stories. This tower extends 18 metres (59 feet) in the ground, by which means a long vertical range is procured, and experiments in height can be made. The extensions of the upper floors referred to consist of a large hall, two stories high, comprising the library and laboratory of the sub-director, M. G. Maneuvrier, whose room adjoins it; the next floor has a dark room for optical researches. Lastly, on the third floor are three small rooms for private students. It may also be added that this tower connects the different parts of the laboratory with the physical amphitheatre, and with the collections of apparatus for the various courses. Under the large hall on the ground floor there are three cellars completely fitted up as laboratories, and a Gauss magnetometer mounted on solid stone pillars. On the ground floor there is a dark room isolated by three stone pillars, and used for electrical measurements and measurements of precision.

It will thus be seen that the laboratory is very complete in itself; but the money allowed for its maintenance (12,000 francs) is quite insufficient, when the general expenses, experiments, and course of lectures are taken into consideration. Nevertheless, the work of the students who have been through the laboratory is a proof of the thoroughness of the instruction. MM. Bouty, Pellat, Foussereau and Leduc (professors of physics at the Sorbonne) all studied at this laboratory, and qualified for their doctor's degrees in it. Several well-known Roumanians and Russians studied there also, and M. Benoît, director of the Bureau of Weights and Measures of Sèvres, wrote his thesis under Jamin. The laboratory has, indeed, become celebrated by M. Lippmann's own work, for it has all been done there, from the investigations on the electro-capillary phenomena to the wonderful discovery of colour photography. It is, therefore, to be hoped that the additional funds required will be forthcoming, and that the enlarged Institute may be even more successful than the old one.

We are indebted to the editor of *La Nature* for the accompanying illustration of the laboratory

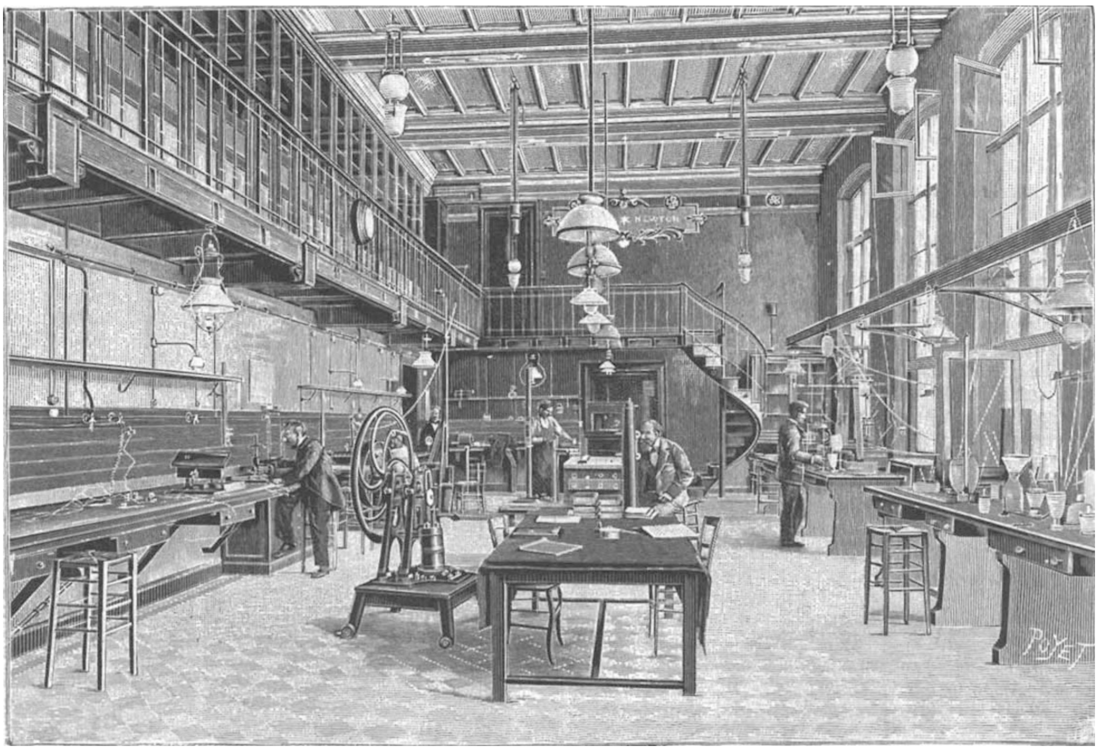

FIG. 1.—New Physical Research Laboratory at the Sorbonne.