first method. In the Reports of the Liverpool Compass Committee and in Mr. Towson's "Information for Masters and Mates regarding Ship's Magnetism," instances of perplexing changes in the compass are given, and are referred to the same cause. The "sluggishness" of ship's magnetism, according to which it depends generally in part on the influence experienced some time before the time of observation, and not wholly on the influence at the time, seems to have been first definitely noticed and discussed scientifically by Sir Edward Sabine in his analysis of the results of the magnetic observations in the Antarctic Exploring Expedition of Sir James Ross in the *Erebus* and *Terror*, in the years 1840–41.

The practical rule and caution given above is of great importance in the navigation of iron ships. The amount of the error which may be found cannot be predicted for ships in general, nor for any particular ship except after much experience and careful observation. A small effect of two or three degrees,[1] such as that referred to in the Admiralty Manual as found in M. Gaussin's experience, may be observed in the course of quietly swinging a ship by hawsers or steam-tugs. If the ship under way is steamed round on the different courses the amount of the "Gaussin error" may generally be greater than if she is hauled round by warps; but we must not be sure that it will be so, because the *shake* of the screw which enhances the magnetisation on the east or west courses may shake it out again before the observation is made on the north or south courses.

A good practical rule in correcting the compass is, after having got it quite correct on the north and south courses, correct just half the error which is found after that on the south and north course, in the regular swinging of the ship.

The warning at the head of this article is particularly important for ships of war after firing guns when on easterly or westerly courses; if the course is then changed to north or south, and particularly if, after the firing, the change of course is effected under canvas, without the shaking of the ship's magnetism produced by the engines and screw.

The warning is also very important for ships steaming through the Mediterranean eastwards or westwards, and then turning south through the Suez Canal or north round Cape St. Vincent; and for ships steaming eastwards from America and then turning northwards or southwards into St. George's Channel.

MATHEMATICAL DRAWING INSTRUMENTS[1]

IN his preface the author states that we nowadays expect to find somewhere in print an account of the little mysteries of any particular art, and that partly with the hope of enabling this expectation to be fulfilled, and partly to meet the constant inquiries made respecting certain of the more complicated instruments manufactured by him, he has written his book. The author offers as an apology for any shortcomings in his work, that he is conscious his powers are greater with the lathe and file than in the ways of gentle rhetoric. In our opinion this is unnecessary; we would rather have had the file marks more distinct, and the technical details of construction not so carefully polished out in the work before us as in the well-finished instruments for which the author is so well known. The drawing instruments in most common use, pen, compasses, and dividers, are first described, and the patterns most recommended are illustrated; the type of these instruments now in use seems to meet all requirements, and if of the best quality, appears to require little or no improvement; the needle-point, however, shown on p. 34 (Fig. 1), adapted to compasses or pricker, is an improvement in steadiness on the old form, which was always liable to a little play. The earlier chapters will probably be of use to the beginner in facilitating his choice of the requisite instruments for his work, but he must recollect that dexterity in their use,

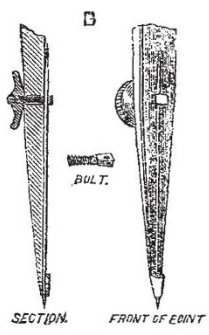

FIG. 1.

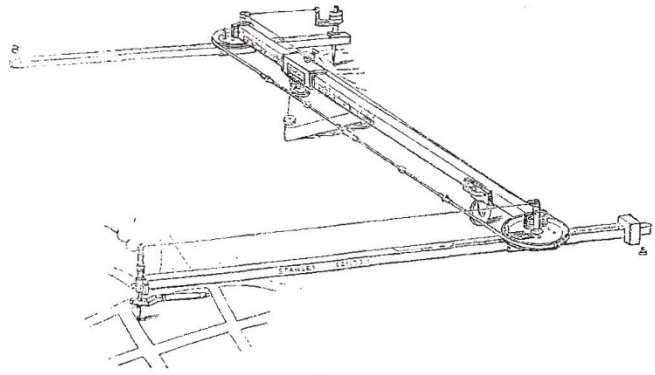

FIG. 2.

even if of the most improved form, can only be acquired with very considerable practice; much time and temper may be saved by the use of good instruments, and there is nothing particularly meritorious in the production of good work with bad instruments if good ones are within his reach.

Of the more complicated instruments next described, some must be regarded rather as mechanical curiosities than of every-day use; others, however, are indispensable where accuracy and the saving of time are of importance; as chief among these we select the eidograph and planimeter. A plan can be reduced or enlarged by dividing it into small squares and filling the details contained in each square into the corresponding squares ruled on the sheet prepared for the copy. This is a tolerably rapid process when the plan is simple in character, and with the help of proportional compasses a good draughtsman may attain considerable accuracy, but for a complicated plan or where great exactness is required, either the pentegraph or eidograph is indispensable. The author justly expresses astonishment at the little use at present made of the eidograph as compared with the pentegraph; the latter as made in this country appears for large work a most clumsy contrivance, offering much unavoidable resistance to motion, and even if made on the most improved Continental pattern is much less handy than the former. The eidograph, as improved by the author, is shown in the cut (Fig 2).

[1] Much greater effects than this are actually found in the cases of gun-practice and of long steaming on easterly or westerly courses referred to below.

[2] "Mathematical Drawing Instruments," by William Ford Stanley. (London: E. and F. N. Spon, 1878.)

The main bar is supported and turns on the pivot carried by the triangular weight; its position with respect to the pivot is adjusted by sliding longitudinally in the box fitted with clamping screw and vernier. On vertical pins at the ends of the main bar turn the two equal pulleys shown; attached to these on their under sides are small boxes also fitted with verniers for the longitudinal adjustment of the two transverse bars. On the similarly situated ends of the transverse bars the tracer and pencil point are carried. When the permanent adjustment of the instrument has been made the transverse arms are parallel, and the pulleys being of equal sizes any rotation given to one communicates an equal rotation to the other by means the flat steel band passing tightly round both; thus the parallelism of the arms is maintained in any position. If now the temporary adjustments are so made that the ratio of the two parts into which the axis of the pivot divides the main beam is equal to ratio of the lengths of the corresponding transverse arms measured from the axes of the pulleys to the pencil and tracer, it is evident that each of those latter is at the apex of a similar triangle, and that the line joining them passes through the axis of the main pivot. Thus the path described by the pencil point is similar to that described by the tracer. The graduations on the bars provides the means of setting the instrument in the required ratio. In the old form the distance between the axes of the pulleys was divided into 200 equal parts, the graduations reading each way from the centre. The transverse arms were made of equal length divided into 200 parts, also reading each way from the centre. For enlargement the setting would be on one side of the centre in each of the three bars and for reducing on the other side. In the improved form shown the tracer and pencil are made interchangeable, and thus the graduation on one half only of each bar is required, while at the same time part of the half arm, B, is dispensed with, making the instrument more handy. In the figure the instrument is set for reducing. The setting is obtained as follows:—Let $\frac{a}{A}$ be the ratio of the scales of the original and reduced plan, and x the reading on the graduations, then for the similar triangles we have $\frac{100 - x}{100 + x} = \frac{a}{A}$, or $x = 100. \frac{A - a}{A + a}$. The chief improvements introduced by the author in the construction of the eidograph consist in making the pencil and tracer interchangeable, which is a considerable simplification, and the introduction of the small roller under the larger arm of the main beam. The improved instrument is stated to be capable of making a reduction down to one-eighth, while the old form certainly became unmanageable at anything beyond one-third.

There is perhaps no instrument whose true value is so little known in the drawing-office as Amsler's Polar Planimeter. The accurate measurement of an area bounded by curved or irregular lines is daily required; and although this can be effected readily and correctly by the aid of the polar planimeter, it is usually laboriously performed by cutting up the area into triangles whose areas are separately determined, or by the measurement of ordinates.

The instrument may be described with the assistance of the figure (Fig. 3). The weight retaining the pin below it at a fixed point, forms the centre about which the more distant arm revolves; to the other extremity of this arm is pivoted a rod carrying a tracing-point at its free extremity. A small roller is mounted on this rod so that its axis is in a line passing through the tracer and pivot at its ends. The roller is provided with a thin projecting edge and is retained in contact with the paper and free to rotate on its axis during any motion given to the instrument. The rotation of the roller is read off from the graduations on its rim by means of a vernier, the number of whole revolutions being shown on the small dial driven by a worm wheel and screw-pinion on the roller-axle. Any motion on the surface of the paper that is given to the point of contact of the roller is resolved into two components, one at right angles to the axis of the roller which is recorded by the dial and vernier readings, and the other parallel to the axis which is a sliding of the roller longitudinally, and is not recorded. To measure the area inclosed by a boundary line as shown in the illustration, the tracing-point is adjusted to any point of the boundary, the dial and wheel are then read off; the tracing-point is then carried round the boundary-line, carefully following it throughout until the starting-point is again reached. The dial and roller are then read off, and the difference of the readings gives the actual area in square inches, or any other units for which the instrument has been graduated. We may now attempt an explana-

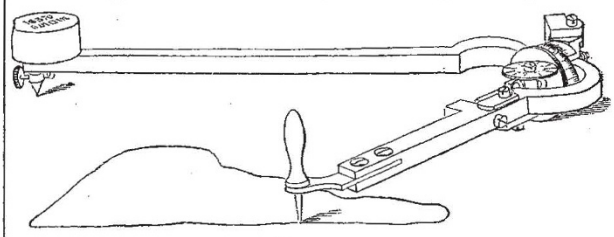

FIG. 3.

tion of the principle of the instrument. Consider first the motion of a straight line parallel to itself. The motion of the centre of the line is compounded of a motion at right angles to it, and one in the direction of its length. The area passed over by the line is equal to its length multiplied by the distance travelled by the centre at right angles to its length.

If, however, the line be moved, not parallel to itself, but into any other position, it could have been made to reach this position by first moving parallel to itself until its centre reached its new position, and thus, by a rotation of the line about its centre as a fixed point, it could be made to assume the position sought. If a figure representing this be drawn it will be seen that, when the movement is small, the area passed over by the line is approximately equal to its length, multiplied by the per-

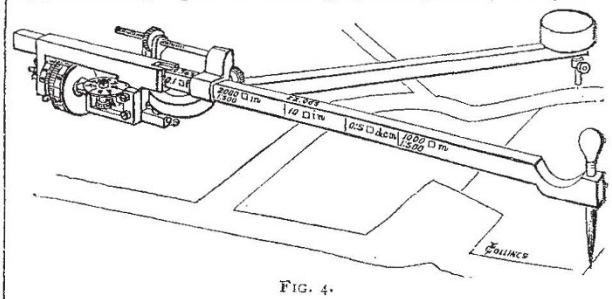

FIG. 4.

pendicular distance traversed by its centre, as before, and that, when the movement is diminished indefinitely, the area described is in the limit equal to the length multiplied by the perpendicular distance traversed. Now let a roller be mounted at the centre of the line, so as to rotate about it as axis, and let it be so graduated on the rim that the length of one division, multiplied by the length of the line, is equal to a unit of square measure. Then, as the line passes from one position to another, parallel to the plane of the paper, the roller will record the sum of the separate infinitesimal movements of the line at right angles to its length, and will thus, by the graduations on its rim, read off, say, at the point of contact with the paper, give the area passed over by the line. Let l = the length of the line, Δx = the perpendicular distance travelled by the roller. Then, in the

limit, $l\,dx$ = the element of area described. In passing over a finite area this will equal $\int l\,dx = lx$, where x is the whole distance recorded by the roller. If now the roller be mounted at a distance r from the centre of the line, in traversing the element of area as before, it will first record $l\,dx$ in its motion parallel to itself, and then, as the line turns about its centre, it will either add or subtract from that reading an amount corresponding to the arc of the circle of radius r, through which it turns; the roller will thus show $l\,dx \pm r\,d\theta$, where $d\theta$ is the small angle turned through. In traversing a finite area this will record $lx \pm r\theta$ where θ is the angle between the initial and final positions of the line. It is now obvious that if the initial and final positions of the line are parallel or coincident, the area passed over by the line will be equal to the area recorded by the roller, even though it were not mounted on the centre of the line, as the second term in the expression just given vanishes. Returning now to the illustration, we see the line represented by the rod carrying the roller, its two extremities being the tracer and the axis of the pivot. Assume that the tracer is placed at the extreme right of the area to be measured: by moving it to the extreme left the roller is made to record an area differing by $\pm r\theta$ from the whole area between the initial and final positions of the rod, and bounded by the portion of the circle described by the further extremity of the rod and by that portion of the boundary of the area traversed, r and θ having the meanings previously assigned to them. Let the tracer be now carried round the boundary back to its starting point on the other side of the area; the roller will now revolve the reverse way, and will subtract from its previous reading an area differing by $\mp r\theta$ from the area contained between the two positions of the rod, the arc described by the pivot and the portion of boundary traversed. It is now apparent that the reading of the roller gives the difference of these areas, which is that of the figure required (Fig. 4).[1] A different form of the polar planimeter is shown in the second illustration, and is provided with an adjustment for varying the effective length of the arm carrying the tracer, by which means the dial and the graduations on the roller are made to show the area to different scales. Mr. F. J. Bramwell was, we believe, the first to publish an intelligible description of the planimeter. This the author refers to, but has rendered it incomplete and far from lucid by condensing it; we would, however, refer him to a short account of the instrument published by Mr. F. P. Purvis in the *Philosophical Magazine* for July, 1874.

With this sketch of two of the most important instruments described by Mr. Stanley, we must conclude our notice of his book. We hope the publication of the new edition may lead to a more extended employment at least of these, and that the favour now shown throughout India and the Colonies, as well as England, for the instruments manufactured by the author's firm may be sufficient inducement to keep them up to their present high standard.

[1] It is here assumed for simplicity sake that the points at which the motion of the roller is reversed are at the extreme right and left of the figure.

NOTES

THE announcement that Dr. W. B. Carpenter is about to retire from the post of Registrar of the University of London will be received with general regret. He has filled the office for twenty-three years.

PROF. MAREY has been elected to fill the place of the late Claude Bernard in the Section of Medicine in the Paris Academy of Sciences.

THE tenth annual report of the U.S. Geological and Geographical Survey of the Territories, in charge of Prof. Hayden, will be ready for distribution in a few weeks. The report has been in type nearly a year, but has been delayed on account of the engraving of the plates. These are now completed and the report will be issued at once. It contains 546 closely printed pages octavo, with eighty plates, sections, maps, &c. Fifty of the plates illustrate the remarkable cliff dwellers in Southern Colorado and Northern New Mexico. This is the last annual report pertaining to Colorado and contains a very interesting series of chapters on the geology of that remarkable country. On the whole this report will prove one of great popular interest and ought to have been published in great numbers. Only 4,500 copies have as yet been ordered. About 250 pages of the eleventh annual report of the field work for 1877 are in type at the Public Printing Office. This will contain a detailed description of the geological and geographical features of Southern Wyoming and Idaho. The reports of Sir Joseph D. Hooker and Dr. Asa Gray will give this volume a high character as well as great popular interest. 10,000 copies have been ordered by Congress. There will be very extended geological reports by Messrs. Endlich, White, St. John, and Peale, and geographical reports by Messrs. Gannett and Wilson, and special reports by Leidy, &c., &c.

VARIOUS items on electric lighting are to hand. It is telegraphed from Washington, December 7, that Mr. Edison's application for a patent for his electric light has been favourably passed by the Patent Office, and that the letters patent were to be issued on Tuesday. The *Journal* of the Society of Arts for December 6 contains a useful *résumé* of the practical application of electricity to lighting purposes, by Mr. J. N. Shoolbred. A new system of electric lamp has been invented in Paris and will be experimented on shortly in public. The carbon rods are four in number, as in the Rapieff system, but instead of crossing at an angle they are arranged in two parallel lines. The consumption of carbon for electric lighting is increasing so rapidly that M. Carré, the well-known Paris maker, is extending his works. He is manufacturing now at the rate of 2,000 meters a day. The electric light illumination has been prolonged, by a vote of the Municipal Council of Paris, up to January 19, for the Avenue de l'Opéra and the front of the Legislative Palace. The city engineers have received orders to prepare, during the interval, a report on the several systems which are now in operation or may be proposed.

THE New York papers report that Mr. Edison has stated that he has made an improved receiver for his telephone by means of which persons standing 15 feet from the instrument can hear a whisper uttered miles away.

AFTER the masterly works of Tschudi on "Animal Life in the Alps," and of Heer on the "History of Vegetation in Switzerland," another work likely to be of high value is announced,—H. Christ on the plants of that country—"Das Pflanzenleben in der Schweiz." The interest of the work is all the greater that Switzerland contains on its narrow area nearly all the diversity of plants which grow in middle and northern Europe. Many years' research of the author in the field, his previous works on separate parts of the Alps, as well as his connection with the botanists of Europe, have enabled Dr. Christ to publish a work which may be expected to range with those above-mentioned. It will appear in four fascicules, with many illustrations, and four maps of vegetable zones, one of which, the distribution of grapes and of several plants of the Föhn and lake regions, will appear this month. The whole work will be finished about the spring of 1879, the first half fascicule having just appeared.

A NEW Botanical Society has just been formed at Munich. the president is Prof. Robert Hartig, and the vice-president Dr. Arnold, an eminent lichenologist.

HERR ALBERT KÜPPERS, an eminent sculptor at Bonn, has