errors cannot be produced by contraction, expansion, or bending of the tube. It is not liable to get out of adjustment, and errors of adjustment are easily recognized, and as easily rectified. On this point the Ordnance Select Committee report: "One of the great advantages of this instrument is its length of radius;* an error of 0.10 inch in either of the levels will represent an angular error of only 8.5 in the total depression, and this is a far larger error than is possible without great negligence, such as an observed leak in one of the floats, or its free movement being in some way checked."

Naval and Hydrographical Telemetry. By DR. A. GURLT.

From the London Mechanics' Magazine, December, 1865.

The following observations on the telemetric methods employed at sea, and a description of the new naval and hydrographical telemeter invented by M. Hermann Gurlt, engineer, Royal Prussian Navy, are intended as a supplement to a paper on telemeters by the late Mr. Archibald H. Bell, Royal Artillery, which appeared in the *Mechanics' Magazine* of November 3d and 10th. In that paper the various methods and instruments which have hitherto been in use on land for estimating distances are ably discussed. Amongst the latter the telemeters of Cavallo, Rochan, Professor Piazzzi Smyth, Lieutenant-Colonel Clerk, Otto Struve, and the instruments invented for the use of coast batteries only by Colonel Shuttleworth, Captain Jerningham,

and the deceased author himself. As the methods and instruments therein described are, however, not applicable for naval purposes, the following remarks on methods of naval telemetry may prove accept-

* 100 inches has been selected as the distance between the floats.

able. Mr. Bell says with regard to these: "We require to estimate distances on board ship, *where not only the object, but also the observer, may be in motion.*" This is certainly the most complicated case of all, and as to instruments which will meet it, the author remarks justly: "This requirement is one of the navy rather than of our own profession, but it is of equal public importance, and though there are many difficulties in this form of the problem, there is every reason to believe its solution to be quite practicable and that it will be some day effected." This difficult problem has found a satisfactory solution already, through the invention of the instruments of M. Hermann Gurli; and of which it is now proposed to give a description. Mr. Bell is not quite correct in remarking that all telemetric methods and instruments depend upon one fundamental principle, and upon which all our efforts to estimate distances must be built, viz: that, knowing the base of an isosceles or of a right-angled triangle, we can ascertain its height by measuring the vertical angle, as we shall see that scalene triangles may be used for this purpose as well, supposing that there are other elements known by which their values may be ascertained.

One of the commonest methods of estimating at sea the distance between two ships, is to measure with the sextant the angle α of the supposed right-angled triangle (Fig. 1) ABE , in which $BE = a$ represents the height of the other ship's mast, which is supposed to be known. The distance AB or d is then found after the formula $d = a \cot. \alpha$ by a very simple and easy calculation, for which purpose even tables may be prepared representing the value of d for the limited number of values a and α . This method appears to be very easy, but it is little commendable, as it admits of very considerable errors, and for the following reasons: The correctness depends, in the first instance, on the knowledge of the real height of the other ship's mast, which can only be guessed, and is consequently a source of great error. Besides, even if the real height were known, in case the ship rolls or is inclined leeward, the observer never knows how much of the real height he can see; and supposing the mast to be inclined leeward 39° out of the vertical line, the difference between the real and apparent height would produce an error as great as one-fourth of the distance. Besides the uncertainty of a , even the value of angle α is difficult to ascertain on board ship, as two points—say, the masthead and the part where it appears over the bulwark—must be simultaneously observed. Lastly, this method is not at all adapted for operations against coasts.

A second method is based upon the *exactly* known height of the observer in the rigging above the level of the sea. In Fig. 2, the distance AM or d of the other ship M , is ascertained by measuring from the elevated stand-point O , the angle λ which the two lines OM and ON form; the former being a line drawn from the observer's eye to the ship's water-line, the latter one to the horizon. As the angle AON is known for the different values of $AO = h$, *i. e.* length of base-line of the triangle AMO , the angle AOM or α is ascertained by deducting λ or $NO M$ from NOA , and the triangle supposed to be right-

angled, the distance d is found from the formula $d = h \tan. \alpha$ for which tables might easily be calculated. Although this method is founded on a known instead of a guessed base-line, it is subject to several sources of errors, which affect its correctness considerably. It is evident that this correctness is much influenced by the correct observation of angle α , which, however, is hardly possible, as the observer has to lay his instrument simultaneously upon two objects, and as this angle is necessarily small from the limited height of the base-line h . To this we must add that even the base-line is influenced by the oscillations of the vessel, and its value consequently much varied, and that it is impossible to lay any instrument exactly upon the water-line of a ship at sea, and much less so upon the horizon. From all this it follows that this method must needs be very incorrect, and as it is not applicable whenever the horizon is not visible, that is, when covered by coasts, thick weather, powder, smoke, &c., it is evident that it is very little use at all.

A third method is based upon the same formula as the one just described, but it has the advantage of a constant base-line $AB = a$, (Fig. 3,) fixed along the deck of the vessel. At B is a sighting instrument, so arranged that its axis forms a right-angle with the base-line; and at exactly the same moment when the object M, either by turning the ship or by any movement of the object M itself, passes before the sight, another observer, stationed at A, measures the angle α , and the distance $d = a \tan. \alpha$ is then easily ascertained. This, theoretically, very simple and—owing to its long permanent base-line—much favored method is, however, in practice hardly applicable, as for every observation the vessel requires to be brought exactly in such a position that her base-line forms the desired and supposed right-angled triangle with the lines AM and BM, which, however, is not very easy to accomplish. Besides, it labors under the disadvantage that the observation can only be made at a certain moment, and does not allow any repetition. From this it will be seen that the telemetric methods hitherto in use at sea are extremely imperfect, and that any method or instruments which will permit of accuracy in measuring distances at sea, both for purposes of naval gunnery and of hydrographical survey, are a real desideratum. This difficult problem appears at last to have found its solution by the method and instruments of M. Gurlt, so that little remains to be desired. M. Gurlt's new method rests—like all other military and naval telemetric methods—upon trigonometric principles; but as it is based on the measurement of any scalene triangles by means of a very ingenious instrument, its application is far more manifold and accurate than that of any other at present known, and as it can be used when either the observer or the object, or both, are in motion without any loss of accuracy, it must be admitted to fulfil even the most sanguine expectations. In the triangle CDM , (Fig. 4,) the two distances d_1 and d_2 are ascertained from the known base-line $CD = \beta$ and the two adjoining angles α and β after the formulas $d_1 = \frac{c \sin. \epsilon}{\sin. \gamma}$

and $d_2 = \frac{c \sin. \alpha}{\sin. \gamma}$. The great superiority of this over all other methods consists in the exactly simultaneous observations of the two angles α and β , it being entirely indifferent whether they are right, obtuse, or acute, and in the use of a permanent, unchanging base-line. The method is simply carried into practice by measuring along the deck the constant base-line CD , and in placing at each end of it one of Gurlt's telemeters. The same object or part of an object, the distance of which from the base-line it is intended to ascertain, is then sighted with the telescope of each instrument, so that, following the motions of the object or those of the observer's vessel, it is always kept covered by the cross-hair centres of the instruments, when, at any given moment, both telescopes can be simultaneously fixed in their position through the action of two powerful electro-magnets, which are attached to each instrument and brought into play by a galvanic battery. The two observed angles α and β are then read, and they furnish the necessary elements for the calculation of the triangle sought. As this method must increase in accuracy with the length of the base-line, it is clear that CD should be made on board ship as long as possible, and as this length is practically unlimited on shore, it is evident that this method is of great value for the purposes of coast defence. Its very great accuracy, however, renders it most valuable for the hydrographical survey, which almost constantly has to solve the problem of the inaccessible distance, *i. e.* to find the distance from each other of two points M and M_1 (Fig. 4) which cannot be approached. It is only necessary to measure the triangles CMD and CM_1D to find the angle $\delta = \alpha - \alpha_1$ and $\delta_1 = \beta_1 - \beta$; and, from two sides and the enclosed angle $M M_1$ or m , is ascertained in the triangle $CM M_1$,

$$m = \sqrt{d_1^2 + d_3^2 - 2 d_1 d_3 \cos. \delta},$$

and in triangle $DM M_1$,

$$m = \sqrt{d_2^2 + d_4^2 - 2 d_2 d_4 \cos \delta_1}.$$

In order, however, to save the trouble of calculation, which would require some little time, and to comply with one principal requirement of a good telemeter, which Mr. Bell justly says is its capability of being used with rapidity, and showing the result at a glance, M. Gurlt has invented another auxiliary instrument, the "constructor," by which the measured triangle can be reconstructed *en miniature* in a few seconds and its values d_1 and d_2 read direct from a graduation.

The *telemeter* is, of course, and angle-measuring instrument, and its essential parts consist of an astronomical telescope, movable round a horizontal and vertical axis, and of a graduated semi-circular limb, upon which any angle between 0° and 180° may be read by means of a vernier and microscope, which are fixed to the telescope. The telescope rests with its cylindrical pivots upon a support, which is fastened to a circular base-plate, and can revolve with the same horizontally round a conical pivot. This pivot rests again in an universal joint fastened to a tripod. The base-plate bears two electro-magnets, which may swing slightly round a horizontal axis, and which are armed with

two pole pieces. Below this is another horizontal circular base-plate of a little larger diameter, which rests on the same conical pivot and bears two standards, in which the graduated semi-circular limb rests with its horizontal axis in such a manner that both the axis of this limb and that of the telescope coincide in one line, which is at right-angles with the axis of the conical pivot. In order to arrest the telescope it bears upon its pivots two vertical and semi-circular arcs of iron, and the lower bottom plate on its circumference a ring of iron; both act as armatures to the electro-magnets, one pole of which is attracted upwards by the vertical arc, and the other downwards by the horizontal ring, whenever an electric current is allowed to pass through the instruments. It is thus possible to fix both instruments simultaneously by magnetic attraction of four poles in each. The telescope bears a catcher by which it communicates to the graduated limb its vertical oscillations, whilst it slides along the same when turned sideways. The angles read upon it are formed by the base-line between the centres of both telescopes and their respective optical axes. The *constructor* is composed of two graduated arcs, round the centres of which two long arms can turn, each being provided with a vernier, micrometer, and microscope near the circumference of the arcs. The distance between the centres of these arcs represents *en miniature* the base-line on deck of the vessel, and by fixing the movable arms with screws upon the angles which were observed with the telemeters, they construct the measured triangle, and the values for d_1 and d_2 may be read from their graduation, where they intersect each other. The foregoing observations will doubtless contribute to the general knowledge and just appreciation of M. Gurlt's ingenious telemetric instruments, which will be found highly useful and accurate for all requirements of hydrographical survey, naval gunnery, and coast defence.

MECHANICS, PHYSICS, AND CHEMISTRY.

Considerations on the Loss of the "London." By WILLIAM FAIRBAIRN, C.E., F.R.S., &c.

From the London Journal of Science, April, 1866.

The introduction of iron as a material in constructive art has been attended with great advantages. For the purposes of ship-building it has given greatly increased strength, and afforded facilities for obtaining new forms, which, aided by the power of steam, have ensured a rate of speed in vessels never before attained in naval history. It has, moreover, furnished the naval architect with a material of immense value as regards construction, and its careful distribution in the shape of ribs, frames, and the sheathing of vessels cannot be too highly appreciated. As compared with the best English oak, it exhibits four times its powers of resistance, and it has, in addition, the double advantage of being almost perfectly homogeneous and free from the defects of open joints, which, in the case of the planking of wooden vessels, require to be caulked. With all these advantages,