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,

iron constructions are surrounded with many dangers when entrusted to the care and superintendence of incompetent persons; in such hands there invariably exists a want of proportion in the formation of iron vessels, which exhibit defective powers of resistance, and such other abnormal conditions as might prove destructive to the efficiency and ultimate security of the structure. It is, therefore, necessary that the naval architect or builder should be conversant with the properties of the material employed, whether considered separately or in combination; and, moreover, he should be satisfied that the vessel, when finished, is capable of permanently resisting the forces of tension and compression, and all the varied strains to which she is subjected when afloat.

In laying down the lines of a ship, all these conditions should be carefully and deliberately considered. It is also of importance to take into account the forms or lines of least resistance, such as a fine entrance at the bows, and an equally clear run at the stern, if high speed is the object to be attained. In such cases, these forms are highly advantageous for vessels navigating rivers and smooth water, but in those intended for long sea voyages, and having to contend with the waves of the Atlantic, or the rolling seas of the Cape, it is questionable whether or not some slight sacrifices should be made to speed, and some modification effected in the form of the bows and stern, in order to meet all the requirements of a safe and convenient vessel intended for the double purpose of carrying passengers and cargo.

I have been led to these particular considerations, not so much from the lamentable accident which overtook the *London*, as from the conviction, that the safety and success of a vessel does not depend so much on its speed as upon its sea-going properties and sound construction. If, for example, we take one of the present iron clippers—which make such quick voyages—with her sharp bows and fine proportions, I am of opinion that she is neither the safest nor the best description of vessel to contend with a heavy sea in foul weather. In the first place, she is a *diver*, which cuts into the sea and rises with difficulty from a *bath*, which covers her decks with water as she pitches from sea to sea. But these are not the only objections to vessels of this form, as repeated immersions of this kind are exceedingly uncomfortable to those on board, and cause the ship to lift some tons of water before her buoyancy is restored to meet the next and every other succeeding wave into which she plunges in a rolling sea. It is not my intention from these observations to depreciate the value of speed either in the Royal or Mercantile navy. On the contrary, I think it is the duty of every ship-builder to approximate as closely as possible to the lines of least resistance, which, in my opinion, ought to be carried to its utmost limits in smooth water, but in smooth water only.

In the construction of vessels of war, it was found expedient to rectify this want of displacement at the bows by projecting the submerged portion of the hull forward in the shape of a ram, not so much, however, for the purpose of attack, as to give buoyancy to the ship, and to enable her to rise more lively upon the sea. These defects of construction were observed in the iron-plated frigates *Warrior* and *Black*

Prince; the former vessel pitched and rolled heavily in the Bay of Biscay from similar causes, which from the first have been observable in all our high-speed ships. Viewing the subject in this light, it may not be out of place to suggest that all passenger and emigrant ships should be modified in their construction, so as to give increased displacement at the bows and stern, but more particularly at the bows, where they require buoyancy, having to encounter the force of a large body of water rushing over them and scouring the decks from stem to stern. Many of us remember the bluff, round bows of vessels of the last century, and how they rolled and pitched in a gale of wind. They were, however, short and compact, and although deficient in speed, they were, nevertheless, dry and excellent vessels at sea.

For several years I have endeavored to impress upon the minds of naval architects and others the necessity of increased strength on the upper decks of sea-going vessels, in order to balance the forces of tension and compression, and the double bottoms on the cellular principle of construction. The ultimate strength of a vessel is the resistance of its weakest part, and, this being the case, it is evident that it is of little or no value to have a strong double bottom if the deck is liable to be torn asunder by the alternate strains of a vessel pitching at sea. That these strains, often repeated, lead to fracture does not admit of doubt, and it has been proved by experiment that, under these circumstances, time is the only element in the endurance of the structure, and this varies according to the intensity with which the strains are produced. I offer these remarks from the conviction that heretofore the decks have been the weakest parts, and that several iron vessels have broken right in two from the constant working of alternate strains at midships along the line of the decks. I have, also, by way of illustration, compared an iron ship to a hollow girder, supported at each end and resting on the middle, for the exclusive purpose of showing the alternate changes to which she may be subjected if stranded or placed in the dangerous position of rising and falling on rocks in a heavy sea. Exceptions may be taken to these views, but they nevertheless exemplify what is necessary to be observed in the construction of a strong ship, and I may probably be excused the comparison, when the object in view is to effect security in the construction of our iron vessels.

I have been confirmed in my opinions on the forms and strain of vessels, from such facts as I was able to gather from the narrative of the loss of the ship *London*. From the accounts and the different statements of the witnesses examined before the Commissioners appointed by the Board of Trade, I was unable to discover any serious defect in the construction of the ship. On the contrary, I have reason to believe that both material and workmanship were perfectly sound, with the exception of the combings of the hatches, which it would appear were imperfectly secured. As respects the design, I have assumed that she inherited the extremely fine lines at the bow and stern already described, and to which I have directed attention, and additional weight is given to this opinion by the manner in which the vessel behaved at sea. Taking all the circumstances into account,

as also the statements of the different witnesses, with regard to the rigging and the state of the decks, I arrive at the conclusion that the ship did not founder from any serious defect of construction, excepting only the insecurity of the hatches, but from the hurried manner in which vessels are sent to sea, with their decks crowded with coal, hampers, and a variety of articles always dangerous and always objectionable in long and narrow vessels that are low in the water and liable to ship every succeeding sea. If these matters and the upper rigging had been properly cared for, there would have been no broken jib-boom to batter to pieces the combing of the hatchway, and instead of the *London* being entombed with all on board at the bottom of the Atlantic, she would, by this time, have been well advanced on her voyage to Australia.

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Jets of Water.—*Experimental data arranged, and some practical hints,*
By S. W. ROBINSON, C. E.

The laws which govern the issuing of water from orifices of various forms depart so widely from mathematical theory, that it becomes necessary to adhere to the former in considering all questions relating to jets of water. These are only known from actual experiments, a large number of which have been made by numerous experimenters, mostly in Europe. The results of these experiments are certain numerical quantities, or co-efficients, each showing the deviation of the actual from the theoretical result for the particular case under consideration. In varying the conditions of the orifice, the fluctuation of the co-efficients is considerable, and is of great importance in all calculations pertaining to dynamic head, size and form of the orifice, quantity, the altitude and amplitude of the issuing jet.

It is sometimes desirable in practice to vary part of the conditions above-named, without changing others. This can only be accomplished by a thorough knowledge and judicious use of the experimental data, together with theoretical formulas. In this paper I propose to give some of the most important results of both theory and experiment upon jets of water, and show the use of both in a few examples.

The theoretic velocity with which water escapes from an aperture in a vessel, is the same as the acquired velocity of a body having fallen from a height equal to that of the water-level in the vessel above the orifice, which is—

$$v = \sqrt{2gh}, \quad . \quad . \quad . \quad . \quad . \quad (1)$$

in which h is the height, and g the force of gravity at the place.

If s equals the section of the orifice, the quantity, or flow of volume, called the efflux, or discharge, will be the product of the sectional area by the velocity, or

$$Q = sv = \sqrt{2gh} s, \text{ or } = svt, \quad . \quad . \quad . \quad . \quad . \quad (2)$$

for the time t , s being the base and vt the length of the volume. This is the theoretic discharge.

The actual discharge is only secured by an application of the co-