THE RUSSIAN IMPERIAL YACHT, "LIVADIA"

IT is not surprising that the character of the great steam-yacht *Livadia*, just launched upon the Clyde for the service of the Emperor of Russia, is exciting wide-spread interest. Since Noah built the Ark, no floating and moving structure has been constructed in such direct contrast as this vessel with all that has gone before it. Every other ship afloat has, in its chief features, been a development of the ships that preceded it, not excepting even the circular ironclads of Russia, for they were not the first circular vessels that had been designed and constructed, and although they had some steaming pretensions, these were too moderate to challenge seriously either the principles or the practice of naval architects. In the new yacht of Admiral Popoff's design, however, we have a steamship that, by its very existence, challenges the fundamental principles upon which fast passenger steamers are constructed by all the rest of the world.

We give herewith illustrations, of which the first (Fig. 1) is an external view of the *Livadia* as seen out of water; it is taken from a model which was constructed under the care of Admiral Popoff, and shows at a glance the general form of the ship. Another (Fig. 2) is a cross section, showing among other things the transverse distribution of the boilers and machinery. The third (Fig. 3) is a plan showing the horizontal distribution of the same, and indicating more clearly than the other the positions of the three propelling screws.[1] It is obvious that such a form of vessel, propelled in the manner exhibited, suggests many questions of scientific interest; but most of these will be best discussed after the steam trials of the vessel have taken place. For the present it will be sufficient to take notice of the general characteristics and qualities which she presents to view.

It is desirable at the outset for the reader to observe that the *Livadia* consists of a shallow hull 235 feet long, 153 broad, and drawing, when supporting all its burdens, but 6½ feet of water. From a foot or two above the water's surface arch upwards and inwards with considerable curvature until they each meet (at about one-sixth of the whole breadth of the ship from the side amidships) the fore and aft sides of a naval palace, which extends from stem to stern. Although the width of the ship at the water-line is 153 feet, her width at a few feet above the water-line is therefore much less—about 110 feet, we believe. In smooth water, therefore, the resistance to onward motion will be those encountered by a vessel 153 feet broad and 235 feet long; but when the ship gets into heavy seas they will be free to pass over her low sides, and the ship that will have to divide and encounter them will be 110 feet by 225. As the object of this vessel is to furnish ample accommodation for the Emperor and his suite at sea, it may be fairly presumed that the width of the superstructure has been kept greatly within that of the hull proper, and the accommodation thus restricted, for the purpose of materially improving the behaviour of the vessel at sea. The arrangement will doubtless contribute greatly both to the speed and to the steadiness of the ship in great waves, its value for diminishing rolling having already been demonstrated in the circular ironclads, which have superstructures of less width than the ship, and which are remarkably steady even in seas that roll freely along the decks of the hulls proper.

The primary and chief fact concerning the anticipated steadiness of this exceedingly short, broad, and shallow ship, is that it is to be secured by means the very opposite of those which have lately obtained in this country, viz., by aid of enormous stability. Since the general acceptance of Mr. Froude's theory of rolling, the aim of the naval architect has been to send his ship to sea with sufficient stability for safety, and with no more than is ample for that purpose; because steadiness at sea is, under the modern theory, promoted by keeping the stability or righting force as small as possible, within the limit just named. The metacentric height, which is from 12 to 15 feet in the American monitors, which have great proportionate breadth of water-line, has been restricted to 6, 5, 4, and even less than 4 feet in many of our large war ships; indeed the *Sultan*, which is one of the steadiest of our large ironclads, has a metacentric height of only 2½ feet, while the *Inconstant's*, the steadiest of our unarmoured ships, is but very slightly in excess of this. This reduction of metacentric height increases proportionately the "period of oscillation," and makes vessels reluctant to accept the disturbances which waves endeavour to impose upon them. But while the tendency of modern science has thus been to diminish metacentric height and stability, the effect of the *Livadia's* form and proportions will be to give her enormous metacentric height and stability, the object in both cases being identical, viz., improved steadiness in waves. Nor is this course pursued, strange as it may seem to some, and violently antagonistic as it is to modern practice, without the sanction of science. For while a ship with very small stability, and consequently very long natural period of oscillation, is ordinarily secured against rolling by her slowness to accept the wave impulses, the ship with very large stability, and consequent very short period of oscillation, is ordinarily secured against excessive rolling by the very readiness with which she accepts those impulses and conforms to the mean movements of the waves. It is true that in the latter case the exemption from rolling motions is not so great as in the former, because a certain considerable amount of rolling is undoubtedly and necessarily involved in this conformity to wave motions; but this amount of rolling is very much less than that to which a ship is exposed which has neither stability so small as to render her comparatively indifferent to wave-pressures, nor stability so large as to force her to keep her decks approximately parallel to the wave-surface. Ships with intermediate degrees of stability are liable to roll much and to accumulate large rolling motions, especially when subjected to successive impulses from similar waves, whereas the ship of enormous stability, while always obeying each wave, is by that very means exempted from the tendency to accumulate the effects of a succession of waves. In all this reasoning—the generality and meagreness of which we fully recognise—it is of course assumed that the waves in question are of sufficient magnitude in proportion to the size of the ship to stand in individual relation to her. The immense breadth of the *Livadia* will doubtless preserve her from being rolled by small waves, including under that designation waves which would cause many ordinary ships to roll with violence. As regards longitudinal rolling, which is usually called pitching, if we neglect the onward motion of the ship, and consider the matter from the same point of view as that just adopted in speaking of transverse rolling, we may say with confidence that the longitudinal stability of the *Livadia* will be in excess of the transverse, and that no excessive pitching need be feared. Owing to the shortness and light draught of the vessel, she would probably (if not advancing) tend to accompany pretty closely the motions of the wave-surface when heading to waves of sufficient size to cause her to pitch. As her length is so small (less than half that of several transatlantic steamships now at sea), the vertical motions of the bow and stern will of course be correspondingly small for given angles of pitching.

It is when we come to consider the case of her enormous steam power being applied to force her ahead through large waves that we experience some difficulty in predicting her behaviour. For we here touch upon a question which has been but very imperfectly investigated; we might even say, has scarcely been more than

[1] We are indebted for the second and third engravings to the kindness of the editors of *Engineering*; the first has been specially engraved for us.

mentioned. A few facts and figures bearing upon it may nevertheless be given. It is estimated that a wave with a 4-seconds period and 82 feet long advances at a speed of 12 knots an hour; an 8-seconds wave 328 feet long has a speed of 24 knots; a 12-seconds wave 740 feet long a speed of 36½ knots; and a 16-seconds wave 1,300 feet long a speed of 48½ knots. If the *Livadia* were steaming at 14 knots against waves equal in speed to her own, she would of course encounter them at a speed of 28 knots, and that is a speed corresponding to a length of wave of about 450 feet, whereas the waves which she would actually be meeting would be but little over 100 feet in length. Again, if we may for a moment imagine her to be steaming at 18 knots an hour, and encountering similar waves, she would of course be meeting them at a speed of 32 knots an hour. But a wave of that speed would be nearly 600 feet long, whereas that which she would, under the last hypothesis, be encountering would be only 100 feet long, as before. It is obvious, therefore, that so short a ship, steaming at high speeds, would develop conditions unknown alike to vessels of low speed (such as sea-going vessels of her small length usually are when steaming against head seas) and to vessels of high speed but of great length. If we take for example the case of waves about 500 feet long from hollow to hollow, and therefore of a half-length of about 250 feet, it is obvious that whereas a fast steamship 500 feet long would receive the support of a second wave while the crest of a previous one still gave her bodily support, the *Livadia* is so short as to be capable of steaming down the wave slope, at an angle to the horizon approximately equal to that of the slope itself. If doing this at a speed of 15 knots an hour, or 25 feet per second, with the on-coming wave advancing upon her, as it would be, at 30 knots an hour, or 50 feet per second, it is easy to see that the behaviour of the vessel would be of an unusual kind. We do not give this as by any means the most notable or critical of the cases which might be selected, but it will serve to show that Mr. Froude was not speaking heedlessly when he said that the purely circular ships would tend to "dive," and to indicate that those persons are probably correct who see in departure from the circular form in the present case evidence, not so much of a desire to diminish resistance, as of a desire to correct the diving propensities of very short ships.

And this brings us to notice the steaming qualities of the *Livadia.* The enormous steam-power with which she is being supplied has naturally excited much notice, and the *Times* gave an interesting comparison between her power and proportions and those of the *Shah.* It will assist the further elucidation of the subject if we invite attention to a different kind of contrast, and compare the *Livadia* with the largest and most powerful of our finished armoured turret-ships, the *Dreadnought.* This huge ship, which steams at 14½ knots per hour, although very much more than twice the immersed size (displacement) of the *Livadia,* has very much less steam-power. The following is a comparison between the two ships:—

	Dreadnought.	*Livadia.*
Length	320 feet ...	235 feet.
Breadth, extreme	64 ,, ...	153 ,,
Immersed depth of hull (mean)	23 ,, ...	6½ ,,
Displacement	9,100 tons ...	3,900 tons.
Indicated horse-power	8,200	10,500

Allowing for the curvature in the form of the hull at and near the bottom, we should of course more than double the *Livadia's* displacement by carrying her sides at the load-water line vertically upwards, and immersing her another 6½ feet; we should probably, by this process, bring her displacement up nearly to that of the *Dreadnought.* As between the two ships, all this extra displacement is, so to speak, saved in the *Livadia,* while, as regards the steam power, hers is in excess of that of the *Dreadnought* by more than 25 per cent. It will be seen from these conditions under what immense advantages the experiment of driving a broad and shallow ship very fast is to be carried out in the Imperial Russian yacht. So far as is known, the designer of the *Livadia* has not promised more than 14 knots of speed; but if we allow her the same speed as the *Dreadnought* (14½ knots) she will have a large excess of steam power (no less than 2,300 I.H.P.) applied to the propulsion of a hull weighing very much less than one-half the weight of the ironclad. The speed reached by the latter vessel was sustained throughout a six hours' trial.

As the *Shah* is a long fine-lined ship, 15 feet longer than the *Dreadnought* and 12 feet narrower,[1] with about the same mean depth, the *Dreadnought* may be regarded as a considerable departure from her in the direction which has been pursued so very much farther in the *Livadia.* It will be instructive therefore to compare these two vessels—

	Shah.	*Dreadnought.*
Length	335 feet ...	320 feet.
Breadth, extreme	52 ,, ...	64 ,,
Depth (mean)	23 ,, ...	23 ,,
Displacement	5,900 tons ...	9,100 tons.
Indicated horse-power	7,500	8,200
Speed	16½ knots ...	14½ knots.

If we compare the performances of these two extremely different ships—different as regards length and breadth, but not as regards depth—we shall find a material reduction in the steaming efficiency of the short and broad ship, but not one of so marked a character as many might anticipate. Applying to both the well-known formula for comparing displacements, powers, and speeds, viz.:—

$$\frac{\text{Speed}^3 \times \text{Disp.}^{\frac{2}{3}}}{\text{Ind. H.-power}},$$

we have—

Shah ... ... 195 | *Dreadnought* 163

Or, viewing the matter with reference to the midship sections propelled through the water, or to the volumes of the excavated channels, and adopting the Admiralty formula—

$$\frac{\text{Speed}^3 \times \text{Mid. Sec.}}{\text{Ind. H.-power}},$$

we have—

Shah ... ... 587 | *Dreadnought* 480

Here we have a loss of, say, 16 per cent. upon the performance constants as regards displacement, and a loss of more than 20 per cent. as regards midship section, by passing from the fine narrow form of the *Shah* to the broader and bluffer form of the *Dreadnought,* observing that the loss would probably have been in greater proportion had the *Dreadnought* been of no more than equal size or displacement with the *Shah.*

Although the *Dreadnought,* as compared with the *Shah,* advances towards the *Livadia* type, the advance is but very small indeed, the *Livadia* being much more than double the breadth of the *Dreadnought* upon a length of 75 feet less. We have in the great Russian yacht an experiment lying far outside of all former experience, and ranging itself under no laws or formulæ with which naval architects are familiar. But it may be well to exhibit her in the guise of the formulæ which we have just employed, and to do this first upon the assumption of a 14 knots speed, and secondly upon that of a speed of 17 knots—the highest, perhaps, which Admiral Popoff has allowed himself to hope for even in his most sanguine moods, and equal probably to that which his ardent disciple and assistant, Capt. Goulaeff, has ever evolved from the most plastic of his calculations—although we must acknowledge that we cannot say this with any great confidence in view of the published paper of the latter

[1] The *Dreadnought's* breadth diminishes by some feet, we believe, at a depth of 6 or 7 feet below the water's surface, but this will not materially interfere with the comparison about to be given.

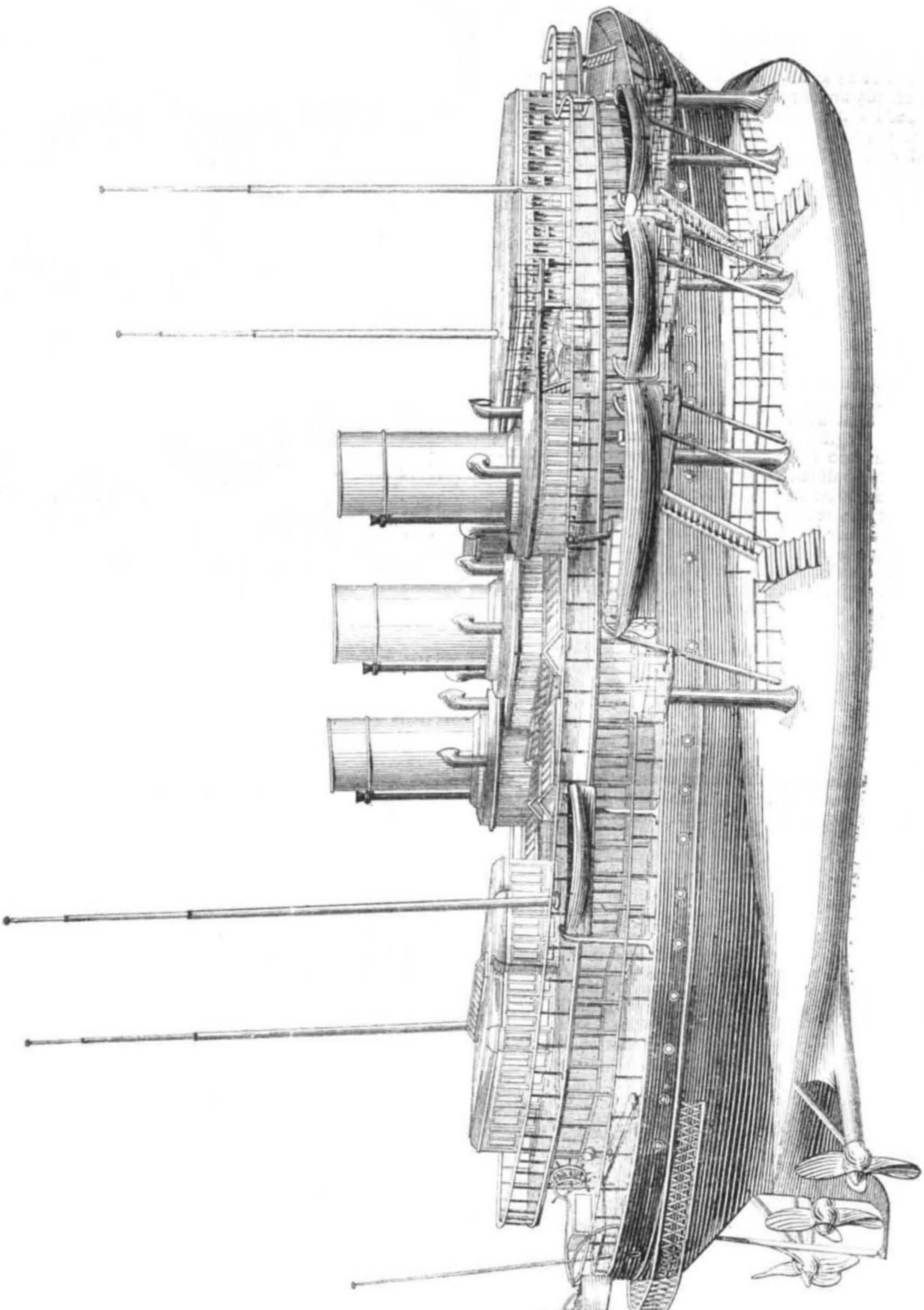

Fig. 1.

officer. The formulæ give the following results for the *Livadia*:—

	Speed 14 knots.	Speed 17 knots.
Displacement constants	65	116
Midship sec. ,,	234	419

These figures illustrate the margins within which the performances of the *Livadia* may range when steaming at above 17 knots and 14 knots respectively. It cannot be expected that her constants will fall so low as the former of the pair just given, and therefore it cannot be doubted that her speed will surpass 14 knots.

We have intimated that Capt. Goulaeff, in his paper on

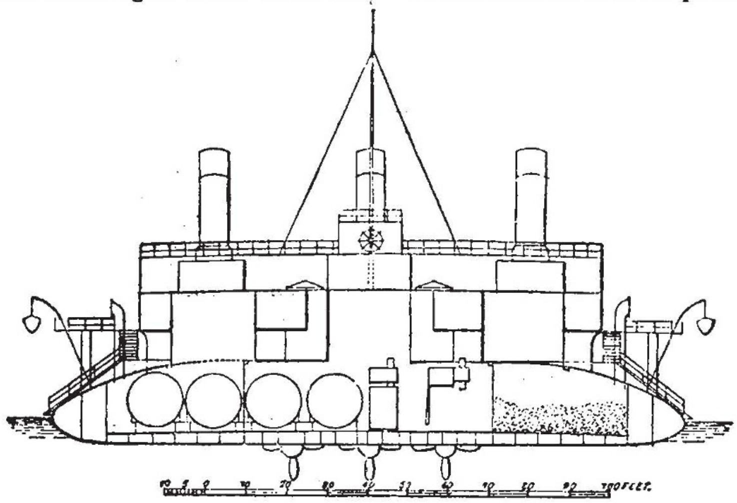

FIG. 2.

"the *Fairfield* yacht of the Czar," has written with great confidence on the favourableness of this vessel's form to speed. He says that an addition of 25 or even 50 feet of length would not have reduced the resistance, the increase of friction being more than the improved form of the water-lines would have compensated for. But it is to her shallowness that he looks for her facility of propulsion, contending that experiments on both a small and a large scale have shown that it is better for speed to have great breadth rather than great depth. He even says that "at certain speeds a very much broader vessel requires only half as much power compared with another vessel of similar form whose draught is double." It is on this ground that he chiefly bases his anticipation that great

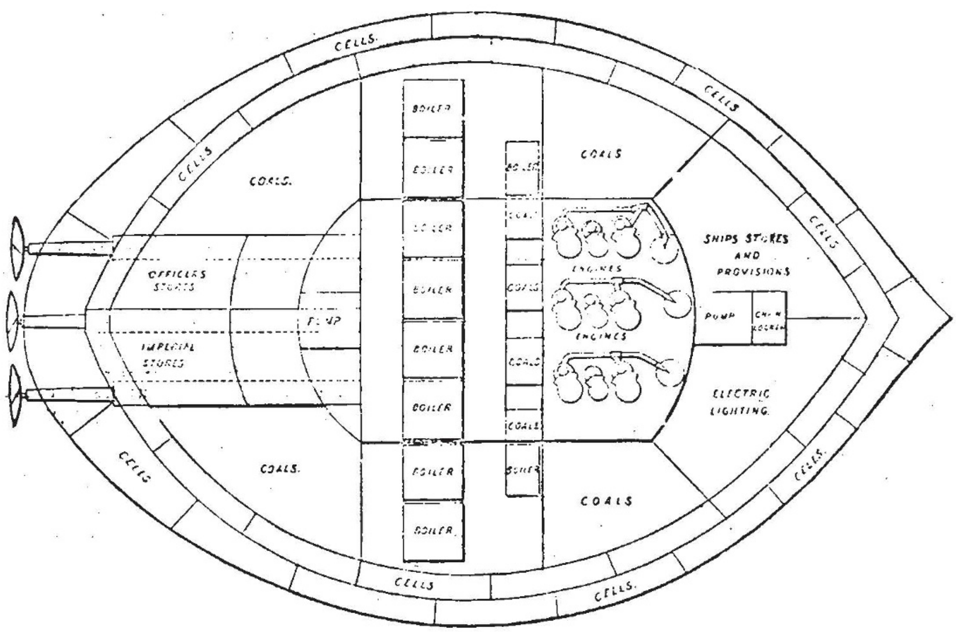

FIG. 3.

speeds are not incompatible with the form given to the *Livadia*. The form of the vessel below water has been very carefully considered. Capt. Goulaeff says:—

"The form of underwater portion was made a subject of very careful study. Besides the great experience of the designer of the ship, Admiral Popoff—experience which he derived by spending the greater portion of his lifetime either on the ocean or in constructing novel ships and trying them at sea—Dr. Tideman, member of the Academy of Amsterdam, was invited to assist in the determination of questions connected with the resistance of the yacht. In the case of this shallow-draughted vessel, the fine lines must be the vertical sections, whereas the fine lines of the ordinary steamer are the water lines or horizontal sections. Such change has been brought about by passing from long, narrow, and deep forms of ordinary vessels to the proportions of short, broad, and shallow ones; and, as has been demonstrated by experiments with paraffin models, the sharpening of buttock lines is more essential in this case than sharpening of water lines. In other words, if the motion of an ordinary vessel may be compared with that of a wedge propelled vertically, the motion of the yacht ought to be compared with the same wedge propelled through the water horizontally. On looking at the stern of the actual vessel you will observe that the whole motion of the water between the stern tubes will be effected solely in the direction of the vertical sections, or the buttock lines."

It is needless for our purpose to consider the minor details of a vessel so fraught with features of extraordinary interest. It may be well to point to the fact that the ship is to be steered, not by rudders, but by her screw propellers only, of which she has three of equal diameter (16 feet), as illustrated in our engravings. These screws are spaced $18\frac{1}{4}$ feet apart, the central one being in the line of keel. Each screw has its own engine of 3,500 I.H.P.

We need hardly say we shall watch the trials of this ship when her machinery is completed, and report the results to our readers. Meanwhile we join in the tribute of praise which is being freely accorded in this country alike to her bold and adventurous designers, and to His Imperial Highness the Grand Duke Constantine of Russia, a highly scientific and accomplished naval officer, by whose influence, and under whose personal care, some of the greatest problems in steam navigation are being developed.

NOTES

THE ceremonies at Manchester in connection with the Victoria University last week were as successful as the momentous event deserved. The *conversazione* on Tuesday evening was brilliant and crowded. The meeting on Wednesday for the transaction of the business of the University was harmonious and satisfactory, while the banquet that succeeded was quite worthy of the Corporation, who acted as hosts. The address of that body to the Duke of Devonshire seemed to us to breathe the proper spirit, and to show that Manchester is quite alive to the importance of the great event which has been celebrated. But indeed we did not require any such evidence of the importance attributed to high education in Manchester; as Earl Spencer pointed out, the Manchester grammar and other schools are among the best in the kingdom, and the existence of Owens College itself is proof enough that Manchester thinks of something else besides the most effective way of loading cotton goods. The speeches were all good and appropriate; the Bishop of Manchester was as liberal and fair as he always is, and his claim for freedom of research and belief in his own line was heartily endorsed by Prof. Huxley, who replied to the toast proposed by the Bishop. Prof. Huxley hoped the time would come when such an institution as Owens would be found in every important centre—a hope we heartily echo. Mr. Freeman was forcible and sensible, and of course took occasion to correct the historical inaccuracy of some one who cherishes the belief that the University of Oxford was "inaugurated" in a desert instead of what was at the time a busy industrial centre.

IT is comforting to receive the assurance given by Mr. Mundella at the opening of the Central Schools of Sheffield last week, that as long as he has the honour to occupy the place he does in her Majesty's Government the quality of education and the standard of education should not be lowered. The State, he maintains, having decided that the children of the country should receive education according to their needs and capacities and prospects in life, ought to give that education not only thoroughly, but generously and with an unstinting hand. With such a sentiment actuating the Vice-President of the Council, we feel that elementary education is safe from the raids of Lord Norton and his friends.

A SOMEWHAT laboured and diffuse article on "Scientific Arrogance" in Monday's *Pall Mall Gazette* comes to the following very sensible conclusion:—"It would appear that scientific arrogance, in so far as it has any reality, is but the obverse of popular ignorance. Let the ignorance be dispelled, and the mystery bred of it will vanish. Let some rudiments of exact knowledge, some grounding in the methods of scientific reasoning, and some notions of the nature and ends of scientific work, be made part of our general scheme of instruction, and scientific dogmatism will be impossible. Let the mind be trained betimes to walk modestly and warily, as all true leaders of knowledge have walked, by the light of diligent and patient inquiry, and the spectre of scientific arrogance will disappear." One more argument for the retention of the Fourth Schedule. Perhaps even Lord Norton might put himself to school to some advantage after this recipe.

THE new Matriculation list of the London University bears ample evidence to the success of the step recently taken by the Council in admitting women to its degrees. In the Honours Division the third place is occupied by Edith Sophia Callet, from the North London Collegiate School. Altogether about one-sixth of the names on this Division are those of girls, and the proportion on the other Divisions is quite as great.

THE New South Wales Government have done a creditable thing in erecting an obelisk on the spot occupied by the Transit instrument in the old observatory at Parramatta, established by Sir Thomas MakDougall Brisbane in 1822. The building has long been swept away; many valuable observations were made in it by Mr. Charles Rümker and Mr. James Dunlop, and it was only right that the exact position of the Transit instrument should be permanently marked, so that, if necessary, future verification might be made. The first suggestion of the obelisk was made by Mr. Tebbutt so long ago as 1870, and it is gratifying that the New South Wales Government has so much regard for science as to act on Mr. Tebbutt's suggestion.

WE have a note from General Myer, dated July 1, stating that at the request of Prof. Wild, of St. Petersburg, the date fixed in his letter of May 4 changing the time of taking the International Simultaneous Meteorological Observations to a time thirty-five minutes earlier than at present, or to 0h. 8m. p.m., Greenwich time, is changed from September 1, 1880, to January 1, 1881, a change with which the numerous observers over the world who make the observations from which the U.S. Weather Maps are constructed will doubtless concur.

WE regret to announce the death of Mr. W. A. Lloyd, who has done so much for the improvement of marine aquaria. Mr. Lloyd, it will be remembered, was for long connected with the Crystal Palace Aquarium.

FROM the *Gardeners' Chronicle* we learn that a committee, comprising some of the leading botanists and horticulturists of Berlin, has set on foot a project to erect a memorial stone on the grave of the late Karl Koch, and appeals through the press to his friends and admirers for subscriptions wherewith to carry out the project in a manner worthy of him whose memory it is desired to perpetuate. Subscriptions may be sent to Herrn Späth, Baumschulbesitzer, 154, Köpenickerstrasse, Berlin, S.O., and will be publicly acknowledged.