light produced. So much is that to be anticipated, that I predicted in 1888 that when we got any indications of stars the spectra of which showed that they were really sparse swarms, such as that depicted on the diagram, at the maximum of their luminosity we should get bright lines, and in all probability bright lines of hydrogen, visible in their spectra. It so happened that shortly after this prediction was made—and when a man of science predicts he does it chiefly not for the sake of influencing others, but to point out where the path of truth really lies—I, in common with many other students in this country, received from Prof. Pickering a photograph of the spectrum of that most wonderful of all variable stars, commonly called Mira, or the marvellous star (Fig. 33). We knew before we received the photograph what its spectrum would in all probability be, but the interesting point was to see whether or not there were any bright lines in it. You see there is an obvious bright line at that part of the spectrum which represents the wave-length of one of the hydrogen lines; there is another where the wave-length of another hydrogen line is represented, and there is another very obvious bright line in another part of the spectrum. So that this photograph entirely justifies the prediction that had been made with regard to this class of stars. And so well is that now recognised that, quite independent of the meteoritic hypothesis, one of the most characteristic features of this class of stars is acknowledged to be the appearance at the top of the light curve—at the moment of the greatest giving out of light—the bright lines of hydrogen and possibly of other substances in the spectrum. Forty old variables of this class show bright lines, and twenty new variables have been detected by the appearance of bright lines, *i.e.* bright lines being seen in them suggested that they were variable, and a further inquiry into the old records showed that undoubtedly their light had varied.

J. NORMAN LOCKYER.

(*To be continued.*)

THE INSTITUTION OF NAVAL ARCHITECTS.

THE summer meeting of the Institution of Naval Architects has been held this year in Paris, and has proved one of the most successful gatherings of the kind it has ever been our good fortune to attend. It had become known amongst members for some time past that a very strong Reception Committee had been formed, consisting of many French gentlemen, eminent both in the scientific and naval world. A large part of the week devoted to the meeting was given up to purely pleasure excursions and entertainments. Of these it is not within our province to speak, but it would be ungracious on the part of any English journal, dealing with the meeting in any way, not to say a word in recognition of the generous hospitality so lavishly displayed by all those connected with the organisation of the programme in France.

There were three sittings for the reading and discussion of papers; Lord Brassey, the President of the Institution, taking the chair on each occasion. Members assembled for the first time in the new amphitheatre of the Sorbonne, which had been kindly placed at the disposal of the Executive by the Rector of the University of Paris, M. Octave Gréard. Vice-Admiral Charles Duperré, President of the Reception Committee, welcomed the members, and Lord Brassey responded in a brief address.

The following is a list of the papers set down for reading and discussion on the programme.

"The Amplitude of Rolling on a Non-Synchronous Wave," by Émile Bertin, Directeur des Constructions Navales, and Directeur de l'École d'Application Maritime.

"On Wood and Copper Sheathing for Steel Ships," by Sir William White, Director of Naval Construction, and Assistant Controller of the Navy.

"The M.G. Metre," by Archibald Denny.

"On the utility of making the calculation of the total external volume of ships, and of drawing out the complete scale of solidity, from the triple point of view of tonnage laws, stability and load-line," by V. Daymard, Engineer in Chief of the Compagnie Générale Transatlantique.

"On Light Scantling Steamers," by B. Martell, Chief Surveyor Lloyd's Registry of Shipping.

"On Coupling Boilers of Different Systems," by Pierre Sigaudy, Engineer in Chief of the Forges et Chantiers de la Méditerranée.

"On the Cost of Warships," by Francis Elgar.

"On some necessary conditions for resisting intense firing in water tube boilers," by Augustin Normand.

"On the Niclausse Boiler," by Mark Robinson.

M. Bertin's paper, which was the first to be read, treated a highly technical subject from a strictly mathematical point of view. The author pointed out that perfect synchronism between the period of rolling and of the wave is practically a purely theoretical case. He referred to the latest calculations made which bear upon a large number of particular cases, and also to the principle of the graphic method, which has been previously described, and which is a simple extension of the method employed to determine the amplitude of rolling on a synchronous swell. The subject is one of extreme interest, but we fear we must refer those of our readers who are not acquainted with it to the published paper in the volume of the "Transactions" of the Institution. It would be impossible to give an abstract of M. Bertin's mathematics, or, indeed, to make the matter clear without the diagrams which accompanied the paper. One result, however, which may be quoted, is that M. Bertin confirms the facts brought out by Sir William White as to the great increase of efficiency of bilge-keels in large as compared with small ships. This, as our readers are aware, came somewhat as a surprise to those engaged in these matters. M. Bertin states: "We find, therefore, in bilge-keels a more powerful method of checking heavy rolling than has been foreseen. In a different condition of things, free liquid provides a more rapid means of extinguishing small rolls than could have been foreseen from any calculations founded on the known properties of liquids." M. Bertin states that the question upon which he treats is one that cannot be solved by calculation; accurate observations made at sea are the necessary complement of all the theoretical researches and experimental study made in port.

Sir William White opened the discussion on this paper. It will be remembered that at the spring meeting of the Institution the Director of Naval Construction was unable to be present, owing to a very severe illness. In spite of this, a paper which he had written on the subject now under consideration was read in his absence. His reappearance at the meetings was the occasion of a very general outburst of enthusiasm on the part of the members present, for no one is more popular, and indeed few have done more for the Institution, than Sir William White. Sir William pointed out that for mathematical purposes it was necessary to make assumptions which could be corrected by and applied to practical work. He paid a handsome compliment to the author by coupling his name with that of the late Mr. Froude.

The next paper read was Sir William White's own contribution on sheathed ships. This, as the author pointed out, was a direct contrast to the paper last read, being of a simply practical nature. As is well known, the purpose for which steel vessels of war are sheathed with wood, is in order that they may be coppered, and their bottoms may thus be preserved from fouling. It is needless to say that the wooden planking is applied as a means of preventing galvanic action between the copper and steel. In order to effect this, it is necessary that the planking should be water-tight, for sea water, in contact both with the copper and the steel skin, would set up galvanic action. It may be stated, however, in passing, that if the sea water is not in circulation, the galvanic action will not be intense or continuous, which is a fact that might be anticipated. In order to make the planking water-tight, it was originally thought necessary that a double skin should be used, and very elaborate precautions were taken in regard to fastenings. Sir William White, then Mr. White, came to the conclusion that the double planking was unnecessary, and that with proper care a single skin could be made to answer the purpose required. In this he was opposed by a large number of eminent authorities, but having the courage of his convictions, he introduced the new system into Her Majesty's Navy. The result has justified his anticipations, for after several years' experience, the hulls of ships thus sheathed have not been found to suffer.

Mr. Archibald Denny's paper described a small instrument he has invented by which the metacentric height of a vessel can be ascertained. It is intended for the use of captains of ships, so that they may ascertain the stability of their vessels under various conditions of load and trim. The instrument is simply a spirit-level pivoted at one end and adjusted at the other, by means of a micrometer screw. This combined with a diagram gives the value M.G. The method of using the instrument is given in detail in the paper, and is made clear by means of diagrams.

M. Daymard's paper was of a commercial rather than a scientific interest. We all recognise that our tonnage laws are anomalous. Unfortunately they have become so interwoven with our commercial system, that it would require nothing less than a revolution to reduce them to a common-sense standard. M. Daymard commands our admiration by his courageous attempt, but as was shown during the discussion, the new laws he proposes, however unexceptionable from a scientific standpoint, would introduce undesirable features. As indicated by the title, he proposes to take the whole external volume of a ship in estimating her tonnage and load-line as well as stability. This seems reasonable, but as an illustration of the undesirability of such a law, it may be pointed out that the tendency of the ship designer working for commercial ends, as all designers of mercantile vessels must do, would be to stint engine accommodation to the manifest danger and discomfort of the engineering staff. The subject, is, however, one which we need not pursue.

Mr. Martell's contribution was one full of information and instruction to the designer of light draught vessels. Its value consisted chiefly in the thirteen plates of illustration containing details of construction of a large number of vessels designed for shallow water navigation. The descriptions which accompanied the illustrations were also of great practical information.

M. Sigaudy's paper, on coupling boilers of different systems, was a brief but instructive contribution. The introduction of the water-tube boiler, which may be said now to be complete in the case of small and exceedingly fast war vessels, appears likely to make headway even in craft not of this special description. The water-tube boiler is, however, something new, and the average engineer, engaged in practical work, always shies at novelties. That is but natural, and it is the result of common sense that caution should be observed when risks have to be run. By the system advocated by M. Sigaudy, the risk is reduced to the smallest dimensions. In a tug-boat built by his Company, an ordinary return tube marine boiler is combined with two water-tube boilers. The engineers of the vessel have therefore a steam generator at their disposal, which they thoroughly understand, and which is sufficient to supply steam to drive the boat at moderate speed. Should the water-tube boilers fail, therefore, they would not be left helpless. One advantage of the water-tube boilers is that steam can be raised very quickly, and this is a very desirable feature in a tug which has at times to be used in cases of emergency. The time occupied upon two trials in raising steam was respectively 22 and 23 minutes. The consumption of fuel was 1·78 lbs. per horse-power per hour, which, it need hardly be said, is a very satisfactory result. No trouble has been found, since the tug has been used, to arise from the combination of the two systems of boilers. In the discussion which followed the reading of this paper, Mr. Yarrow stated that a similar system has been adopted by the Dutch Government in some cruisers they are having built. These vessels are naturally of much larger size than the tug-boat described by M. Sigaudy, and their trials will be looked forward to with considerable interest by the naval world.

Dr. Elgar's paper, on the cost of war-ships, constituted a new departure in the annals of the Institution. It has generally been considered, if not expressly stated, that financial questions are tabooed by the Institution. In the case of Government vessels, doubtless more latitude should be allowed, but in any event it is a difficult thing to exclude money considerations from discussions on subjects which have a commercial basis. After all, ships are built to earn money, and even the designer of war-ships has to keep the question of cost incessantly before him. It would be useless, for instance, suggesting a new form of marine engine, however perfect from a scientific point of view or economical in its working, if its first cost were to be prohibitive. In the discussion which followed the reading of the paper, views similar to these were expressed by prominent members of the Institution, and it is probable that more latitude will be given for the future in this respect. For our own part, it will be impossible to abstract, in anything like reasonable space, the vast quantities of figures given by the author of the paper. His analysis of the subject was very complete, and it may be stated, briefly, led to the happy conclusion that dockyard-built war vessels are costing less than they did of old, relatively to the work put into them. It may be stated, although Dr. Elgar failed to point the fact out in his paper, that this happy state of affairs is largely due to the good work he himself did when Director of Dockyards.

The last two papers of the meeting were on the subject of the hour, water-tube boilers. M. Normand, the well-known builder of torpedo boats at Havre, and one of the most scientific and best informed marine engineers of the day, gave a very valuable analysis of the points which should be observed in designing a water-tube boiler. Naturally, circulation occupied his chief attention, and it may be said briefly that if sufficient activity of circulation of water and steam in the boiler can be maintained, that boiler is likely to be an efficient steam generator. How to obtain such circulation is a complex and disputed question, and here we find our own great authority on the subject, Mr. Thornycroft, at issue with the author of the paper. Mr. Thornycroft, as is well known, is a strong advocate of above water discharge into the steam drum. M. Normand, on the other hand, upholds "drowned" tubes. The subject is a large one, far too large for discussion in a report of this nature. To us it appears that M. Normand is not warranted in all the assumptions upon which he bases his conclusion, and further it may be said that Mr. Thornycroft has experimental data on his side in maintaining that the circulation of water is more active with above water discharge than with drowned tubes. Whether with the latter the circulation is sufficiently active for all practical purposes is of course another matter, the bearing of which it remains for practical experience to prove. For, like the problem M. Bertin attacked in his paper, it is not solvable by theoretical analysis.

Mr. Mark Robinson, in his paper, described a very promising form of water-tube boiler which has been introduced in France by M. Niclausse, the inventor. Without illustrations it would be utterly impossible to make the design clear; but it may be said that the principle followed is that of the Field tube, in which circulation is promoted by means of a pipe inside and coaxial with the heating tube. Curiously enough, however, the tubes in the Niclausse boiler are horizontal, or approximately horizontal, so that the circulation is maintained in the "header" which is divided by a diaphragm, the difference between the specific gravities of the water, or water and steam, contained on each side of the diaphragm causing the movement of the water. This boiler appears to be one of great promise amongst water-tube boilers in situations where the highest evaporative efficiency is not required. It is, however, in these positions that the ordinary return tube boiler is strongest. Whether it will be supplanted by a water-tube boiler remains to be seen; but should such be the case, the Niclausse boiler has the anpearance of being a formidable competitor.

No account of the Paris meeting would be complete without reference being made to the beautiful series of photographs shown by M. Bertin in illustration of the movements of ships in a sea-wave. These photographs were taken by the method devised by M. Marey, to which reference has already been made in these columns. A dozen or more different views are given of a ship during its passage through a wave, and the whole movement can thus be fixed and analysed. The value of such data to the naval architect is, of course, immense. In connection with these photographs, which were shown on the screen, there were also exhibited some very beautiful projections of photographs in colours. These were shown by M. Charles Comte, one of M. Marey's assistants. The subject is one which has been attracting attention of late, and has been referred to elsewhere in these columns.

METEOROLOGICAL PROBLEMS FOR PHYSICAL LABORATORIES.

IN response to several requests from both teachers and students for suggestions as to problems that can be taken up in physical laboratories, Prof. Cleveland Abbe gives the following list of subjects, in the *American Meteorological Journal* for May. The initialled subjects are due to Prof. C. F. Marvin.

SUBJECTS FOR EXPERIMENTAL INVESTIGATION.

(1) The internal sensitiveness of thermometers, or the length of time required to bring the top of the thermometer column to the proper reading when the external surface of bulb and stem is kept at a constant temperature below, or above, some initial temperature.

(2) The influence of the wind on the pressure within a room, or other closed space, containing a barometer.

(3) The influence of the condition of any surface (as to