through a friction-roller from a clock furnished with a centrifugal governor, acting by fluid-friction, and balanced so that its speed is not sensibly affected by the shaking of the ground. The clock is started into motion by means of a Palmieri seismoscope, which appears in the figure behind the plate, on the right. This is a small common pendulum whose bob carries at the bottom a piece of stiff platinum wire that projects into a recess in a cup of mercury below—the recess being formed by an iron pin standing lower than the surface of the surrounding mercury. On the slightest shaking of the ground, contact with the edge of the mercury takes place, and this closes a circuit which releases an electro-magnetic detent and starts the clock. This occurs during the preliminary tremors which are usually found in advance of the main movements of an earthquake. The same circuit starts another clock (of the escapement type) which fulfils two functions. It marks time on the revolving plate during a part of the first revolution, and then continues to go as an ordinary clock, so that, by inspecting its dial afterwards, the interval which has elapsed from the occurrence of the earthquake is known, and the date of the shock in hours and minutes is thus determined with as much precision as the phenomenon admits of. This part of the apparatus is omitted from the figure. The two horizontal components of motion are recorded by a pair of horizontal pendulums, set at right angles to each other, but with their indices inclined so that they write side by side on one radius of the plate. The pendulums are supported on a single stand, but with independent adjustments for position and stability. Each has two pivots, consisting of hard steel points, which turn in sapphire centres. At the pivots and at the tracing-points every effort has been made to avoid friction. The indices are of aluminium, and a part of their weight is taken by springs (not shown in the figure), so that their pressure on the plate may be no greater than is necessary to produce a trace on the sooty film. The vertical component of motion is recorded by the instrument which appears behind the clock. A massive bar, free to move vertically about a horizontal axis, is held up by a pair of long spiral springs. Its equilibrium is made nearly neutral by applying the pull of the springs at a suitable distance below the horizontal plane through the axis of support, in the manner described in the article to which reference has already been made. A bell-crank lever with a jointed index gives a multiplied trace of the apparent vertical oscillations of the bar, which correspond to vertical displacements of the ground. In this instrument, as in the others, sapphire centres are used to minimise friction.

Records inscribed on the plate are preserved by varnishing the plate, and using it as a "negative" to print photographs. The motion, as recorded, is magnified to an extent which experience of Japanese earthquakes has shown to be desirable in dealing with disturbances ranging from those which are just recognisable as earthquakes up to those which are to some extent destructive. For great earthquakes, separate apparatus of the same type is designed, in which the multiplying indices are dispensed with, and the scale and style of the other parts are considerably modified.

Another and distinct instrument, also manufactured by the Cambridge Company, is the duplex pendulum seismograph, shown in Fig. 2. A massive bob is hung by three parallel wires from the top of a three-cornered box, and is reduced to nearly neutral equilibrium by being coupled by a ball-and-tube joint to the bob of an inverted pendulum below it. The two form a system which can be made as nearly astatic as is desirable, and so furnish a suitable steady-point for the horizontal part of earthquake movement in any azimuth. The motion is magnified and recorded by a vertical lever geared to the upper bob by a ball-and-tube joint, supported on gimbals from a bracket fixed to the box, and furnished with a jointed index which writes on a fixed plate of smoked glass. Records of the kind which the duplex pendulum gives are of course incomplete in two important particulars: they show nothing of the vertical motion (which, however, is usually a comparatively small part of the whole), and they show nothing of the relation of *time* to displacement throughout the disturbance. But they exhibit very clearly the change of direction which the movements undergo, and the actual direction taken by any pronounced element of the shock. The writer has recently learnt from his former assistant, Mr. Sekiya, now Professor of Seismology in the University of Tokio, that as many as fifteen of the duplex pendulum seismographs are in use by official and private observers in Japan.

The instrument shown in the figures are now on view at the Edinburgh International Exhibition (Court 21, No. 917). Similar sets are being made for the Lick Observatory, California, the Ben Nevis Observatory, and other places. It is scarcely necessary to add that they show the high finish and perfection of workmanship characteristic of the Cambridge Company's manufactures. To Mr. Horace Darwin the writer is especially indebted for a number of suggestions the adoption of which has contributed much to scientific accuracy in details and simplicity in structural arrangements.

J. A. EWING

THE INSTITUTION OF NAVAL ARCHITECTS AT LIVERPOOL

THE Institution of Naval Architects departed this year from their almost invariable custom of holding meetings in London, and had a most successful series of meetings at Liverpool. The papers read were few in number, but they were of special, and, in some cases, unusual interest. The meetings were attended by a large number of the Members of the Institution, as well as Liverpool scientific men, shipowners, underwriters, engineers, and others interested in the subjects of discussion. A local paper was read by Mr. G. F. Lyster, C.E., the Engineer to the Mersey Dock and Harbour Board, upon the Docks of Liverpool; Prof. F. Elgar read a paper upon "Losses of Life at Sea"; Mr. B. Martell upon "The Carriage of Petroleum in Bulk on Over-sea Voyages"; Mr. W. John upon "Atlantic Steamers"; and Mr. W. Parker on the "Progress and Development of Marine Engineering."

Prof. Elgar's paper upon losses at sea has attracted much attention. It contains a general analysis of the losses that happened during the triennial period that has recently caused so much controversy as to whether loss of life at sea is increasing or not, viz. the three years 1881-83. Details are given, in a set of tables appended to the paper, of the steamers and iron sailing ships belonging to the United Kingdom, of and above 300 tons gross register, that were reported to the Board of Trade as foundered or missing during the five calendar years 1881-85. The facts contained in these tables show clearly the great advantage it would be to the shipping community if such information were published periodically in a clear and convenient form. Probably no documents that emanate from any Government Department are more bewildering, or more difficult to extract any tangible information from, than the voluminous and complicated returns of wrecks and casualties, and of lives lost at sea, that are published annually by the Board of Trade. We hope that the attention of the Royal Commission now sitting upon Loss of Life at Sea, has been forcibly directed to the many imperfections and the comparative uselessness of the present published returns that profess to deal with these matters; and that one of the Committee's recommendations will be that something should be done to make them clear and instructive.

There is another cognate matter which we hope will also be dealt with satisfactorily by the Royal Commission, viz.

the manner in which wreck inquiries are now conducted. As matters stand, the evidence obtained at those inquiries, and the rulings that are given by the Courts, have no scientific or practical value. There is no class of quasi-scientific literature that we know of which contains more bad science than is to be found in the rulings of the Wreck Inquiry Courts. Prof. Elgar puts the case very mildly when he says that the returns of the Wreck Inquiry Courts are not all that might be wished as regards the publication of facts connected with losses, and that they are often imperfect and erroneous where difficult technical points are involved. He adds that "this probably arises from the perfunctory character of many of the inquiries; as it has been explained by the Wreck Commissioners that the number of inquiries, and the distant places at which they are sometimes held, often make exhaustive inquiries impossible."

Nothing can be held to excuse imperfect inquiries into the causes of those losses at sea which have formed the subject of so much public discussion and excitement, and respecting which a Royal Commission is now sitting; and nothing would be more likely to promote an increase of knowledge, or to lead to the adoption of precautions for preventing losses, than thorough and trustworthy inquiries into the causes of those losses that so frequently occur.

The conclusions arrived at by Prof. Elgar in his paper, as the result of an examination of the analysis contained in it, are the following:—

(1) The shifting of cargoes is one of the chief causes of the foundering of steamers and iron sailing ships at sea, independently of mere depth of loading.

(2) Dangerous shifting of grain sometimes takes place through hasty and imperfect stowage, inefficient shifting-boards, or weakly-constructed end bulkheads, or through the omission to fit end bulkheads, where such are required on account of the density of the cargo; and dangerous shifting of coal sometimes takes place, because it is carried in compartments that are not fitted with shifting-boards.

(3) Many steamers carrying grain and coal cargoes—notably the class of narrow three-decked steamers built several years ago—are vessels that have insufficient stiffness when fully laden, to resist heeling to a dangerous angle, in the event of cargo shifting or of water getting below.

(4) The effect upon such vessels of the shifting of cargo, and of water below, is generally to hold them over at a considerable angle of inclination, but not to completely capsize them.

(5) Pumping power at the bilges is often an essential condition of preventing loss in such circumstances, and of getting a vessel righted.

(6) The stability of these vessels when laden with the various cargoes they are likely to carry, should be completely determined by calculation before they are sent to sea; and clear instructions, based upon the information so obtained, should be framed for the guidance of those who are responsible for their loading. Such instructions should include particulars of the empty spaces to be left in the 'tween decks, or of the weight of ballast to be carried, or both, for each class of cargo.

(7) All the authentic particulars procurable of ships that have foundered and are missing, and of the circumstances and the manner in which the foundered ships were lost, should be collected and published periodically for the information of the shipping community.

(8) The losses of steamers through the shifting of cargoes seem to be chiefly among the narrow steamers of the three-decked type that were built several years ago. The steamers of that type that have recently been built have more beam and much greater stability than those formerly built, and it may be confidently hoped that the attention which has been given to this matter of late, and the improvements that have consequently been introduced into this type of vessels, will lead to a diminution of losses among them.

Mr. Martell's paper upon "The Carriage of Petroleum in Bulk on Over-sea Voyages" deals very fully with the history of the carriage of petroleum by sea, and the special precautions that are necessary to enable it to be carried safely and economically in ships. Besides those points, however, that are special to the treatment of petroleum as a cargo, there are others which naturally grow out of a consideration of the subject. There is, for instance, the important question of the use of liquid fuel for marine propulsion. The mechanical difficulties involved by this have now been overcome, so that *astatki*, the residuum of crude oil, might be profitably used as fuel for steamers employed upon comparatively short voyages. It is largely and successfully used for marine propulsion on the Caspian Sea, where oil is very cheap and coal is very expensive. The chief obstacle at present to extending the use of this fuel is its cost. The price of *astatki* at Baku varies from 4*d.* to 1*s.* 3*d.* per ton; the carriage by rail to Batoum raises the cost at that port to about 1*l.*; and after adding freight charges for bringing it to this country, its total cost on delivery would, according to Mr. Martell, be not less than 2*l.* 2*s.* From these figures it must be evident that while the best steam coal can be shipped at Cardiff for about 9*s.* per ton, liquid fuel cannot be economically used in competition with it. As the cost of transport of liquid fuel from Baku to Batoum becomes reduced—and this can only be a question of time—there is no doubt that liquid fuel will come into general use for local steamers, and most likely for many steamers trading in the Mediterranean.

Mr. W. John refers, in his paper upon "Atlantic Steamers," to several matters that are of importance to the travelling public. He advocates the adoption of twin-screws in first-class Atlantic steamers as a provision against total breakdown in the event of a shaft, or of any other vital part of the propelling machinery, giving way. He also advocates a middle-line bulkhead, and greater internal subdivision generally, so that ships may be more safe in the event of a compartment being bilged through collision. Mr. John states that improved designs for the Atlantic passenger steamers of the future now form the subject of work and investigation in the drawing-offices of several shipyards. The developments that are taking place are, doubtless, generally in the direction of providing greater safety against accidents to the hull of the ship, or to the propelling machinery, by means of greater internal subdivision and twin-screw engines. Higher speeds than any yet realised are being contemplated by building purely passenger vessels that will carry no cargo; and many improvements of details, which are in the direction of making the accommodation for passengers more like that furnished by a first-class hotel, are also being devised.

Mr. Parker's paper upon "The Progress and Development of Marine Engineering" forms a supplement to one read by Mr. F. Marshall before the Institution of Mechanical Engineers at Newcastle-on-Tyne, in 1881. Mr. Parker traces the progress that has been made in economy of steam propulsion since the introduction of the triple expansion-engine by Mr. A. C. Kirk in 1874. Mr. Kirk fitted triple expansion-engines to the *Propontis* for Mr. W. H. Dixon, in that year, with boilers designed for a working pressure of 150 lbs. per square inch; but the boilers did not prove satisfactory, and were ultimately removed. The next triple expansion-engines were those of the yacht *Isa*, designed by Mr. A. Taylor, of Newcastle-on-Tyne, in 1877; and those of Messrs. G. Thompson and Sons' steamer, *Aberdeen*, which were constructed by Mr. A. C. Kirk, in 1881, for a steam pressure of 125 lbs. per square inch. The *Aberdeen* was the real pioneer vessel of the triple expansion type of engine; as it was proved in her that triple expansion-engines could be made not only to fulfil all the ordinary conditions of working at

sea, but to effect a great economy in coal-consumption. Since then the new system has come rapidly into use, and shipbuilders and marine engineers are now looking in the direction of triple and quadruple expansion-engines for the economical advantages of high-pressure steam in future ships.

It is estimated that the present triple-expansion marine engine, with 150 lbs. of steam-pressure, has an advantage of from 20 to 25 per cent. in economy of coal consumption, over the ordinary compound engine with 90 lbs. pressure, which it is rapidly supplanting. These results have been achieved through a clear appreciation of the waste of energy which is caused by the alternate heating and cooling of a steam cylinder that takes place in consequence of the difference of temperature at which the steam enters and leaves it. The steam-jackets introduced by James Watt as a cure for this were imperfect and wasteful in their action. An effectual remedy has been found as the result of many years of study and experiment by men of science and engineers, by expanding the steam successively in several cylinders, so as to make the variation of the temperature of the steam in each cylinder as small as possible.

NOTES

WE greatly regret to announce the death of Mr. George Busk, F.R.S., the well-known surgeon and naturalist, in the seventy-eighth year of his age. We must reserve a detailed notice of Mr. Busk's life and work.

GEOLOGISTS will be sorry to hear of the death of Mr. Gerrard Kinahan, son of the well-known geologist of the Geological Survey of Ireland. Last October he accepted an appointment in the service of the National African Trading Company. The last letter received from him gave an interesting account of his explorations up the southern tributaries of the Niger. He died on May 23 from a wound with a poisoned arrow in a fight with the native tribes at a place called Anyappa. His training as a chemist and geologist at the College of Science in Dublin and also at the School of Mines in London had thoroughly qualified him for original research, and his quietly enduring temperament and kindliness of nature augured a most successful scientific future, whether at home or abroad. But he has been cut down on the very threshold of his career—another young victim to the dangers of African exploration.

THE death is announced of Dr. R. J. Mann, F.R.C.S., aged sixty-nine. Dr. Mann was for three years President of the Meteorological Society, and was a Member of the Astronomical, Geographical, Photographic, and other Societies. He gave up his medical practice to take a Government appointment in Natal, where he served as head of the Education Department and Medical Officer for many years. On his return, about 1864, he became Emigration Agent for the Colony, and when, some ten years later, he resigned that post, he devoted himself to his favourite scientific pursuits. He was a popular and prolific writer. The protection of buildings from lightning was a subject on which he wrote a good deal, and for which he did much valuable work.

M. CHEVREUL, the illustrious French chemist, will complete his hundredth year on Monday next. A grand *fête* at the Museum in honour of the occasion is being organised. Delegations from foreign countries as well as from the provinces are expected. In one of the *salles* at the Museum there is to be an exhibition presenting a *résumé* of the scientific labours and discoveries of M. Chevreul. The banquet will be at noon, in order that the famous centenarian may himself be present.

OUR Vienna correspondent writes:—"Dr. von Frisch, having recently experimented on preventive inoculations for hydrophobia, has made a preliminary communication to the Vienna Academy of Sciences, in which he states that it was impossible for him to prevent the breaking out of rabies by means of Pasteur's method if the infecting virus (of at least fourteen days' incubation) were administered to previously healthy animals by trepanning. This latter method of artificial infection of animals Dr. von Frisch suggests to be the only safe one. He made his experiments on rabbits and on dogs. At first sixteen healthy rabbits were trephined, and the virus (of sixteen days' incubation) was injected under the dura mater. Fifteen of these rabbits were then subjected at intervals to the usual preventive inoculations, the remaining one not being inoculated. All these animals except one, which, as Frisch believes, was not sufficiently infected, died between the fourteenth and thirty-third day after infection, with symptoms of rabies, and if particles of their spinal cord were injected into healthy rabbits, the latter also became rabid. Similar experiments were then made on dogs, and with the same results. But a series of rabbits infected by subcutaneous injection of the virus, and then treated by Pasteur's method, continue healthy up to the present time."

THE Grosvenor Museum for Chester and North Wales was opened at Chester on Monday by the Duke of Westminster. The new museum is intended as the home of four influential local societies—namely, the Chester Society of Natural Science, founded by Charles Kingsley; the Chester Archæological Society, which is closely associated with the name of the late Dean Howson; the Chester Schools of Art; and the Chester Science Classes. The first floor is devoted entirely to science, except one room to be used as a laboratory, a committee-room, and a model-room for the school of art. The upper floor is entirely devoted to the school of art. In the several rooms there are exhibited specimens illustrative of the natural history of the district, water-colour drawings, collections of antiquities, oil paintings, wood carvings, a collection of pictures by members of the Art Club, appliances for science teaching, memorials of Canon Kingsley and Dean Howson, a collection of objects illustrative of Oriental art, a magnificent collection of tapestry, choice embroidery, lace, porcelain, textile fabrics, &c.

THE autumn congress of the Sanitary Institute of Great Britain will be held in the city of York on September 21 and following days, under the Presidentship of Sir T. Spencer Wells, Bart.

THE summer meeting of the Institution of Mechanical Engineers will be held on Tuesday morning, August 17, and Wednesday morning, August 18, at 25, Great George Street, Westminster. The following papers have been offered for reading and discussion after the address by the President:—Experiments on the steam-jacketing and compounding of locomotives in Russia, by M. Alexander Borodin, of Kieff; on the working of compound locomotives in India, by Mr. Charles Sandiford, of Lahore; description of a portable hydraulic drilling-machine, by M. Marc Berrier-Fontaine, of Toulon; description of the Blackpool electric tramway, by Mr. M. Holroyd Smith, of Halifax; on triple-expansion marine engines, by Mr. Robert Wyllie, of Hartlepool.

THE French Association for the Advancement of Science begins its annual meeting to-day at Nancy.

THE lectures recently delivered at Oxford by Prof. Sylvester on his "New Theory of Reciprocants," will appear in the coming numbers of the *American Journal of Mathematics*. The lectures are presented in quite simple style, and will be exceedingly interesting to all students of the modern algebra, or, more accurately, of the theory of invariants. The first eight or nine lectures will appear in the forthcoming number of the *Journal*, vol. viii. No. 3.

A SOCIETY for the study of anthropology has been founded in Bombay. Before the departure of the East Indian mail the