the same experience if he provided either a similar valve or a reservoir of air of sufficient capacity near the closed end of the *cul-de-sac* (such as exists in the form of branch workings in most mines), from which air could expand and thus wholly or partially destroy the vacuum. If he arranged his experiment in this way, he would have no difficulty in securing propagation by means of a firedamp explosion ignited by a spark, much less by 100 grammes of dynamite.

Many other points of importance might be referred to with advantage, but space would fail us were we to attempt to go further in this place, and the final remark we would make in regard to this series of experiments is that the water employed in damping the dust, which forms globules on the surface of the latter, does not appear to have been applied in the form of an exceedingly fine spray, repeated several times, in succession, with a short interval between each application, and we venture to think that if this had been done the results would have been different from those actually experienced.

The fourth series of experiments was made with the gallery lengthened to 230 metres (251½ yards), although the whole length was not always employed. For the first 32½ yards the form of the gallery was trapezoidal, with a lining of cement, the remainder cylindrical, with a lining of wood and with a floor. The coal dust was prepared from Liévin coal, with 29 to 31 per cent. of volatile matter and 6 to 12 per cent. of ash. The slate dust employed in some of the experiments was obtained from the pit. It contained 9 per cent. of volatile matter and 87 per cent. of ash, and was mixed with marly chalk, clay, siliceous sand, and boiler-furnace cinders. Mixtures of coal dust and inert dust were prepared by grinding them together. The mixture was simply spread uniformly on the floor and not stirred up mechanically before the explosion. The charge employed in creating the explosions consisted of 240 grammes of gelatine dynamite untamped and fired electrically, the axis of the cannon being 15¾ inches above the floor.

Fine dust was spread to a distance of 16½ feet in front of the cannon to insure ignition, but beyond that point coarser dusts ground for a quarter or half hour and even grains were employed.

Some explosions effected with half-hour dust were very violent, traversing the whole length of the gallery in 1½ seconds, with increasing velocity, which exceeded 1100 yards per second at the orifice, while the pressure, which was 28½ lb. per square inch for most of the distance, increased to between 42½ lb. to 71 lb. per square inch at 45 metres from the orifice, and to 156½ lb. per square inch at 11 yards from the orifice. With 900 grammes per cubic metre of quarter-hour dust, the flame traversed the gallery in 1·23 seconds, and the pressure attained 224 lb. per square inch at 10 metres from the orifice.

With a deposit of coal dust containing up to 33 per cent. of slate dust the coal dust was exploded, and the explosion was capable of becoming violent.

Passing over the experiments with dustless, watered and shale dust zones, and those made with obstacles of various heights, placed on the floor and on shelves at the sides of the gallery, we come to what are the most novel, and perhaps also the most interesting, of all the experiments, namely, the efficient results obtained in the way of arresting even violent explosions by placing loose, easily displaced cinders, or, *mutatis mutandis*, half-round sheet-iron tanks 40 inches long by 8 inches in diameter, filled with water on transverse planks one metre apart just under the roof of the gallery. It is to be hoped that these two methods of arresting explosions will be the object of further successful experiments, and it is not improbable that, after all, we may owe to France a debt of gratitude for pointing out a simple and efficacious means of effecting the object which all of us are so anxious to attain. May the present writer suggest in conclusion that possibly appliances of the nature of extincteurs or fire extinguishers, put into operation by the blast which precedes the flame of an explosion acting upon a movable vane which would open the passage for the escape of their contents, might be used instead of open troughs filled with water? The former would possess the indubitable advantage that they would retain their efficiency intact for any length of time; whereas the latter would require constant attention in the way of cleaning and refilling them. W. GALLOWAY.

THE INSTITUTION OF NAVAL ARCHITECTS.

THE spring meetings of the Institution of Naval Architects opened on Wednesday, April 5, at the rooms of the Royal Society of Arts. Owing to the death of Earl Cawdor, president of the institution, the chair was taken by Sir W. H. White, who announced that the council recommended the election of the Marquis of Bristol as president. The grant of a Royal Charter of Incorporation has received the Royal assent. The celebration of the jubilee of the institution, postponed from last year, will take the form of an International Congress on Naval Architecture and Marine Engineering, opening on July 4.

Fourteen papers were read and discussed. The problem of size in battleships was dealt with by Prof. J. J. Welch. Among other points raised in this paper is the contention that large dimensions expose a greater target to attack, a contention which must now be expanded to include the additional menace of missiles from dirigibles or aëroplanes. Assuming the attack to be delivered from a height of one mile, and therefore reasonably out of range of high-angle fire, a hollow bomb carrying 100lb. of explosive would take about twenty seconds to reach the water level, and would then have a striking velocity of about 500 feet per second. In twenty seconds a ship would change position some 540 feet, supposing her to be proceeding at 16 knots, and the probabilities of such a vessel being struck from above would be decreased if, at the moment of discharge of airship weapon, her helm were put hard over. The time, however, would not suffice to allow the vessel to sweep clear of her previous track before the missile reached water level, although the exposed area of deck in that track would be very much smaller than before. The difficulties associated with correctly judging speeds of battleships from the height named, and making proper allowance for cross wind currents, &c., combine to render a hit very uncertain if a single missile only is employed. It is stated, however, that arrangements are being made for dropping a number of such missiles from a single dirigible, in which case this form of attack would become a serious menace. It seems reasonable to suppose that the best protection from such attacks will be found in the counter-attacks by the same type of air-ship, associated with high-angle gun fire from the vessel attacked.

The Hon. C. A. Parsons and Mr. R. J. Walker gave the results of twelve months' experience with the geared turbines fitted to the cargo steamer *Vespasian*. In this vessel, the reduction of speed ratio of 20 to 1 is obtained by means of a spur wheel and pinion having double helical teeth. The vessel has now steamed 20,000 miles, and inspection shows that the wear in the teeth so far seems to be a negligible quantity. With the view of experimenting with different qualities of steel, a pinion of chrome nickel steel of tensile strength 55 tons per square inch, elastic limit 38 tons, and an elongation of 20 per cent. in a length of two inches, was tried and removed after two voyages. The corners of some of the teeth were found to be fractured, probably owing to irregular machining and to the material being too brittle. The original pinions were of mild chrome nickel steel of tensile strength 37 to 38 tons per square inch, and an elastic limit of 32 tons per square inch. These were replaced and have now carried the vessel more than 18,000 miles. A very noticeable feature has been the absence of racing of the engines under conditions when the propeller has been entirely out of the water. It is very difficult to observe any acceleration in the speed of the engines without the aid of a sensitive tachometer. This is owing to the very great angular momentum of the turbine.

Mr. G. S. Baker contributed a fully illustrated description of the National Experimental Tank and its equipment, including the model-making apparatus.

The whole of Thursday morning was taken up by a paper on Diesel engines for sea-going vessels, by Mr. J. T. Milton, of Lloyd's Register, a paper which provoked a very interesting discussion. Inducement to forsake the steam engine for ordinary sea-going vessels will be mainly the question of fuel economy. Even this important point would not of itself warrant a change to a new type of engine unless equal certainty of continuous efficiency on the voyages to be undertaken was provided, that is, as little risk of accident to machinery and as great facility for using temporary expedients for reaching port in case of breakdown of part of the machinery. There must also be a prospect of a reasonable cost of upkeep. Leaving warships out of account, oil fuel is only used on shipboard in those cases where the natural advantages render its use more economical than coal, and by vessels which trade regularly to ports where supplies can be obtained. For the ordinary cargo steamer which has to seek employment all over the globe, coal is still the necessary fuel.

The Diesel engine for marine purposes is made in three forms, viz., as a four-stroke cycle single-acting engine, a two-stroke cycle single-acting engine, and a two-stroke cycle double-acting engine. An auxiliary air compressor capable of producing a pressure of about 700lb. per square inch is required. The author has examined the turning moment diagrams of different arrangements of cylinders, and shows that a four-stroke cycle engine with twelve cylinders, a two-stroke with six cylinders, and a double-acting with three cylinders give fairly uniform Forsion moments, the ratio of maximum to mean being not greater than 1·15. With these numbers of cylinders there is nothing further to be desired regarding steadiness of motion. The Diesel marine engine should be Diesel only as regards the cylinders and their accessories, and should be of the ordinary marine type as regards all the rest of the engine. The question of the auxiliary machinery required is fully discussed in the paper.

Dr. Diesel stated in the discussion that any kind of oil may now be used in these engines, and that the use of the two-stroke cycle may be assumed in future for marine purposes. Some 250 vessels are now fitted or to be fitted with Diesel engines, a large number of these being submarines. The use of Diesel engines in submarines has so extended their radius of action as no longer to limit their use for coast defence merely. About 1000 horse-power is the largest power obtained from one cylinder up to the present, the cylinder being of the two-stroke double-acting type. Some makers are prepared to give higher powers from one cylinder.

Messrs. Richardson, Westgarth and Co., of Middlesbrough, are now constructing a set of single-screw Diesel engines of 1000 horse-power for a 3200-ton ship to the order of Lord Furness. These will be of slow-running type. The Anglo-Saxon Petroleum Co. have on order a single-screw vessel of 4250 tons to be fitted with 1100 horse-power Diesel engines, to be built by an Amsterdam firm.

Considerations affecting local strength calculations form the subject of a paper by Mr. J. Montgomerie. It is a truism that there is no such thing in the calculations dealing with the strength of ships as an actual quantitative stress in tons per square inch. "To design a ship from first principles" is a phrase which is often used in a sense implying far too much. All calculations of the strength of ships are comparative. Structural arrangements of vessels which have stood the test of experience are taken, and are compared and contrasted with those proposed in any given case, or a corresponding arrangement is derived from them which shall be satisfactory in the case being dealt with. It is of importance to eliminate, so far as possible, errors lying at the root of the comparison. For example, the comparison of a beam of symmetrical section with another of unsymmetrical section by use of the ordinary beam formulæ may produce very large errors. Again, errors often arise through want of proper consideration in cases of combined normal and shearing stresses. The effect of altered flexibility in a proposed arrangement often causes an entire change in the basis of comparison, and is generally uniformly neglected. Recent experimental work by Lilly on columns and Bach on flat plates was referred to. In connection with the latter subject comparatively little is known experimentally for rectangular plates fixed at the edges, and Dr. Thearle announced that the committee of Lloyd's Register had made a pecuniary grant to the author of the paper to assist in enabling further experiments to be carried out.

The acceleration in front of a propeller is the subject of a paper, in which Dr. R. E. Froude resists the inroad which a propulsion paper read by Prof. Henderson last year makes upon Dr. Froude's paper of 1889. The principal purpose of the latter was to prove from hydrodynamic theory that, in so far as the fluid acceleration by which thrust is satisfied may be treated as external to the propeller, one-half of that acceleration must take place before the propeller in obedience to defect of pressure in front of it, and the other half after it, in obedience to excess of pressure behind it. Prof. Henderson's paper of last year purports to prove, also from theory, that the precedent acceleration cannot possibly contribute to thrust. In the present paper Dr. Froude reasserts his theory, together with such further considerations as appear to be called for by Prof. Henderson's paper.

Herr H. Frahm contributes a paper giving the results of trials at sea of his anti-rolling tanks. Reference has already been made to Frahm's arrangement in NATURE. When in full action, the tanks on the ss. *Ypiranga* and *Corcovado* exert a turning moment of 2790 foot-tons, thus counteracting wave impulses of equal turning moment. In order to obtain equal efficiency in damping out rolling, the same turning moment ought also to be exerted by any other anti-rolling device, such as a gyroscope, which might be fitted to these ships. It is doubtful if it will be possible to develop the gyroscope sufficiently. The ss. *General* (13,620 tons loaded displacement), of the German East African line, started on her maiden trip at the beginning of March. When crossing the Bay of Biscay, she encountered a storm which made her roll 14° on either side when the tanks were out of action. This was reduced by 7° or 8° when the small fore tank was put into action, and with both tanks in action, the rolling was reduced to 3° in either direction. A large working model was shown in the library of the Royal Society of Arts. The ship was set rolling in a tank by means of an electromotor, operating on the model by means of a very flexible flat spring. The model showed very clearly the efficiency of Frahm's tanks in reducing rolling.

Prof. E. G. Coker describes his optical method of investigating stress in plates of variable sections, and gives some applications to ship's plating. The method has been already noted in NATURE, and it may be now added that the author has developed a method of obtaining the stresses quantitatively. This may be done by subjecting a standard test-piece to such a degree of pull or push that the colour produced agrees with that at a desired point in the body under examination. Or by a method modified so as to get rid of the necessary judgment in matching colours; this modified method may be used in all cases of pull or push stresses, and consists in arranging a simple pull or push member in the same field of view as, and immediately in front of, the object under examination. To determine the stress at any point, the reference member is loaded until the original dark field produced by the optical arrangement reappears. When this happens, the stress in the reference member is the same as that at the point considered, and no correction is required for the alteration in thickness produced by the stress, since both test pieces are in exactly the same condition.

STATE SURVEYS.[1]

THE true economy of executing land measurement of the highest precision as a control upon more detailed work, which can then be done more quickly and at less cost, is now generally admitted, and wherever the area is large such control work is carried out by a central administration for the use and assistance of local surveys. Methods will vary in different areas and with the special object in view, but such coordinated work on a large scale has great advantages over small scattered areas in which work is carried on independently.

(1) The operations of the Survey of India during the twelvemonth ending September 30, 1909, are described in the report which has just been issued. Primary triangulation was carried on in Beluchistan, Kashmir, and Burma over an area of 9600 square miles, besides a certain amount of building and selecting station; the average triangular of three groups completed were 0·41″, 0·6″, and 0·47″. The 10-foot standard bar A having returned from Sèvres, whither it had been sent in 1908 for comparison with the international metre, was recompared with the secondary standard bar of the Survey, and the results show that it is

[1] (1) "General Report on the operations of the Survey of India." By Col. F. B. Longe, R.E. (Calcutta, 1910.)
(2) United States Geological Survey, Washington. Bulletins 434, 437. Spirit Levelling, 1896 to 1909.
Bulletin 440. Results of Triangulation and Primary Traverse, 1906–8.