for power alone, and a sugar factory an equal quantity of coal for boiling purposes, some means ought surely to be found to bring them together, and thus satisfy both demands with a consumption of 23 tons instead of 40 tons.

In discussing the question of the safety of cast-iron economisers, Mr. Stromeyer gives a summary of all the economiser explosions—seventeen in number—reported upon by the Board of Trade since 1882. Only nine of these explosions were destructive, but, unfortunately, none of the inquiries into these mishaps have revealed their true causes. If the Board of Trade inquiries into boiler explosions are to be of value, they ought to be conducted in such a manner that the study of the reports may be of service to engineers who have to design and use the appliances. It would appear, however, that the object which Mr. Stromeyer's association had in view in drawing up the Boiler Explosions Act, 1882, has been entirely lost sight of. It was intended that every explosion should be investigated by an expert, but it was found necessary, in order to get the Bill through Parliament, to add one competent lawyer to the engineering experts. The lawyer has always been made president of the commission, with results which may be imagined. Further, there are probably very few "competent and independent engineers" who are, as required by the Act, "practically conversant with the manufacture and working of boilers," since few engineers pass through the boiler-shop, and fewer still have had to work them. But the Board of Trade has no hesitation in appointing men to make these inquiries who have never even seen the objects which they have to investigate. At a recent inquiry two investigators, both marine engineers, confessed that they knew nothing about land economisers, neither their design, material, manufacture, nor mode of working. As the Board uses a rota, the chances are that these engineers will never again be called upon to inquire into an economiser explosion, despite the knowledge they doubtless gained in the course of the inquiry. In these circumstances it is but natural that many preliminary reports, and nearly all Commissioners' reports, dismiss the cause of explosions with a non-committal remark to the effect that "the boiler burst because it could not withstand the steam pressure."

Mr. Stromeyer suggests, and we strongly support the suggestion, that the duty of investigating boiler explosions should be entrusted to an enthusiastic engineer, who would certainly go into details, and make experiments on the strengths of materials, especially upon the parts of burst boilers, which is scarcely ever done at present; he would also take steps to become acquainted with the influences of working conditions.

The memorandum contains ample evidence, extracted from Board of Trade reports, to justify Mr. Stromeyer's remarks. For example, Report No. 2470, on an economiser explosion, omits to mention certain old fractures. The two "competent and independent engineers" (selected by the Board from among its own staff), together with other engineers, refused in their evidence to admit that an open damper could have caused the failure of any of the pipes, and attributed the explosion to the old fractures. By withholding this information the report deprives the engineering profession of the means of studying the problem of economiser safety.

The fact appears to be that the investigations are carried out by the solicitor of the Board of Trade, who brings forward sworn evidence, though the swearing is not required by the Act, and without any warning to the witnesses, these may now be cross-examined both by their own side and by the Commissioner, and then very often their own sworn evidence is used against them. It is unfair to witnesses who wish to give the Commissioners every assistance, and as the whole atmosphere is now a legal one (even a Lord Advocate once appeared for an insurance company) the technical causes of explosions are scarcely inquired into.

THE BELGIAN ROYAL OBSERVATORY.

IT is pleasant to see that the Brussels Observatory is in a position to resume the publication of its memoirs (Annals of the Belgian Royal Observatory, vol. xiv., part 2). After a discussion of the division errors of the Repsold meridian circle, Prof. Stroobant contributes an interesting essay on the constitution of the ring of minor planets. Tables and diagrams are given of the distribution of the various elements; the striking grouping of the perihelia towards Jupiter's perihelion is already well known, and Newcomb gave an explanation of it from theory. The eccentricities show a similar grouping, high eccentricities being most frequent in the quadrants where the perihelia congregate; this can also be explained by the action of Jupiter. The formulæ expressing the perihelion density (N is the number of perihelia in an arc of 30°) and the eccentricity are:

$$N = 66{\cdot}75 - 31{\cdot}7 \sin(\varpi - 106{\cdot}7^\circ)$$
$$e = 0{\cdot}141 - 0{\cdot}028 \sin(\varpi - 86{\cdot}5^\circ).$$

The ascending nodes show a slight tendency to group towards Jupiter's ascending node; it would probably be easier to study the relations of nodes and inclinations if the elements were referred to the plane of Jupiter's orbit rather than to the ecliptic.

There is an interesting study of the probable total number of asteroids brighter than magnitude 20. From some very faint asteroids discovered by photography at the Lick Observatory, combined with the area of sky covered by the plates, the total 57,000 is obtained. From a study of the number of known planets of different magnitudes the empirical law is deduced that the number per magnitude doubles for a fall of one magnitude. On this basis the total number brighter than magnitude 20 is 100,000. The two estimates are in satisfactory accordance, bearing in mind the large measure of extrapolation employed in each method.

It is estimated that very few asteroids (say twenty) brighter than the 12th mag. at opposition remain to be discovered.

Taking the mean albedo as 0·108 (midway between those of Mercury and Mars) and the density the same as the moon's, the total mass is 1/22 of that of the moon, the planets brighter than magnitude 10 contributing one-third of this total, and those between magnitudes 10 and 11 another one-third.

The third memoir in the volume is on the brightness, colour, position, and parallax of Nova Aquilæ; a large-scale light curve is given extending from 1918 June 10 to November 23. From the end of June until the middle of August there were fairly regular oscillations in the curve, the period being thirteen days. Prof. Stroobant notes two cases of apparent rapid change of light. On August 29 the brightness increased 0·7 mag. in twelve minutes; on October 6 it fell 0·3 mag. in five minutes. Changes like this need verification from more than one station to make sure that they are not due to a local variation in the transparency of the air.

The position and parallax were obtained by observations with the meridian circle. Screens of muslin were placed over the object glass for the brighter stars. The thickest screen reduces the light by

3·2 mag. Two determinations of the parallax are given:

(1) 0·20″ ± 0·05″ M. Philippot.
(2) 0·06″ ± 0·07″ M. Delporte.

Both determinations appear to be improbably large, judging by the small proper motion and the values obtained for other novæ.

A. C. D. CROMMELIN.

THE LIVERPOOL MARINE BIOLOGY COMMITTEE.[1]

THE issue of the thirty-third annual report of the Liverpool Marine Biology Committee, and, as we are informed, the last of the series, is an opportune moment for the publication of a review of the important work that has been done since the formation of the committee in 1885. This report is not the swan-song of a dying enterprise, but rather the triumphant cry of those who have achieved an initial victory that gives hope for a rapid and continuous advance in the future; and, although the old L.M.B.C. ceases to exist, there is every reason to believe that its work will be carried on with increased efficiency by the newly organised staff of the oceanography department of the University of Liverpool.

In the short history of the work of the committee that is published in this report it is clear that a very substantial contribution has been made to our knowledge of the species of animals and plants that inhabit the waters of the Irish Sea, and that valuable information has also been acquired about the many characters of the sea-bottom round the Isle of Man and the north coast of Wales.

All this is necessary pioneer work, although much of it may seem dull and uninteresting when in print. The workmen must learn the use of their tools before undertaking the more serious work of production. But we see in the L.M.B.C. memoirs, of which twenty-three have already been published, in the important investigation of Prof. Herdman and his colleagues on the fluctuations of the plankton, and in the biochemical researches of Prof. Moore and others, that these valuable contributions to our scientific knowledge of the sea have outgrown the "Records" of the early years of the life of the committee.

The work of recording and describing the booty of the sea must, of course, continue; but with the ripe experience of thirty-three years, with the more complete equipment of laboratory space and apparatus, and with the new organisation of the oceanography department of the University, we may confidently look forward to further important developments in the general scientific work of the Port Erin institution.

We may tender to Prof. Herdman our cordial congratulations on his achievements in the past and our good wishes for the full success in the future of the great enterprise which is so largely due to his own personal genius and enthusiasm.

S. J. H.

[1] The Marine Biological Station at Port Erin. Thirty-third Annual Report of the Liverpool Marine Biology Committee. Drawn up by Prof. W. A. Herdman. Pp. 84. (Liverpool: C. Tingling and Co., 1919.)

APPLICATIONS OF INTERFEROMETRY.

IN a report by Prof. Carl Barus, of Brown University, recently published by the Carnegie Institution of Washington, a number of interesting applications of achromatic interferometry are described. In the first chapter a method of measuring small angles is discussed. The general theory of the subject is developed at some length, and a variety of interferometer devices, with mirror, ocular, and collimator micrometers, are instanced. As the achromatic fringes cannot (in general) be found without first finding the corresponding spectrum fringes, the second chapter is devoted to spectrum fringes. The work described in the third chapter was undertaken at the request of Prof. W. G. Cady, in the endeavour to obtain the elastic constants of small bodies. The application of the displacement method proved astonishingly easy in a case where a degree of rough handling is inevitable, but it was found that there lurked in the elastic apparatus some discrepancies, both of viscosity and hysteresis, the nature of which escaped detection after many attempts to locate its origin. The fourth chapter contains applications of the rectangular interferometer using achromatic fringes to the study of gravitation. A method for the determination of the Newtonian constant is worked out. Again, the same interferometer is associated with the horizontal pendulum for the detection of small changes in the inclination of the earth's surface. Series of observations extending between January and August are recorded. In the fifth and last chapter the author deals with the application of interferometers to the study of vibrating systems. To test the method, an examination is made of the vibration of telephonic apparatus. Interference-vibration curves have been obtained for two identical telephonic systems joined directly in series, while these forms subsided completely when the telephones were joined differentially.

RESEARCHES AT HIGH TEMPERATURES AND PRESSURES.

BY THE HON. SIR CHARLES A. PARSONS, K.C.B., F.R.S.[1]

I.

JUST ten years ago in this room Sir Richard Threlfall discussed the effects of temperature and pressure on various substances, and commenced by referring to a suggestion I made in 1904 to sink a bore-hole twelve miles deep in the earth with the object of exploring the region beneath us, about which so little is known. Last summer at Bournemouth I ventured again to direct attention to the desirability of such an exploration in the interests of science generally, and to the possibility that it might ultimately lead to some developments of practical importance and utility.

Ten years ago no experiments had been made on the behaviour of rocks under the conditions existing at great depths below the surface of the ground; but, prompted by my suggestion in 1904, and after some subsequent correspondence in regard to the possibility of the rock crushing in and closing the shaft, Prof. Frank D. Adams, of McGill University, Montreal, commenced experiments on the strength of rocks to resist the closing up of cavities under the conditions prevailing at great depths below the surface. He published the account of these experiments in the *Journal of Geology* for February, 1912.

Adams's method was to place a block of granite or limestone in a tightly fitting cylinder of nickel-steel, which was shrunk lightly around the block to ensure perfect fitting and support; hard steel rams actuated by a hydraulic press were arranged to exert a known pressure against the ends of the block. Two small holes were previously drilled in the specimen, one axial in the centre and one transverse, the diameter of the holes being 0·05 in., or one-tenth the diameter of the specimen. The temperature of the container and specimen was maintained at any desired point up to the softening point of steel. In some experiments no heat was applied, while in others the temperature

[1] Discourse delivered at the Royal Institution on Friday, January 23.