During April the comet passes from near 58 Persei to a little south of η Aurigæ. In the latitude of London it is circumpolar throughout the month.

Search Ephemeris for Comet 1889 V.—The following search ephemeris for the expected return of Comet 1889 V (Brooks) is given by Dr. Bauschinger (*Ast. Nach.*, 3334):—

	R.A. h. m. s.	Decl. ° ′	Brightness.
April 2	20 40 24	−24 9	0·17
6	47 3	23 50	0·18
10	53 35	23 31	0·19
14	21 0 3	23 12	0·20
18	6 24	22 52	0·22
22	12 39	22 32	0·23
26	18 47	22 12	0·25
30	24 47	21 53	0·27
May 4	30 40	21 33	0·28
8	21 36 25	−21 14	0·29

The ephemeris is for Berlin midnight, and the unit of theoretical brightness is that on 1889 July 8, the date of the first accurate observation. When last seen in January 1891 by Prof. Barnard at the Lick Observatory, the calculated brightness was 0·08, so that the comet should even now be brighter than when it was last observed; it is, however, not very favourably situated for European observers. During April the motion of the comet is a little north of the line from ψ to ζ Capricornii.

INSTITUTION OF NAVAL ARCHITECTS.

The annual spring meeting of the Institution of Naval Architects was held last week, commencing Wednesday, the 25th ult., and being carried over Thursday and Friday, the two following days. The new President, the Earl of Hopetoun, who has succeeded Lord Brassey, occupied the chair throughout the meeting.

There was a long list of papers to be read, the following being on the agenda:—

(1) "Watertight Doors, and their Danger to modern fighting Ships," by Captain the Right Hon. Lord Charles Beresford, C.B., R.N.

(2) "Watertight Doors," by Colonel Nabor Soliani, Director of Naval Construction, Royal Italian Navy.

(3) "Some Geometry in Connection with the Stability of Ships," by J. G. Bruhn.

(4) "The Causes of Mysterious Fractures in the Steel used by Marine Engineers as revealed by the Microscope," by A. E. Seaton.

(5) "The Measurement of Feed and Circulating Water, &c., by Chemical Means," by C. E. Stromeyer.

(6) "Salvage Appliances," by J. G. Kinghorn.

(7) "Compound Marine Boilers," by Colonel Nabor Soliani, Director of Naval Construction, Royal Italian Navy.

(8) "Water-tube Boilers," by J. Watt.

(9) "Circulation in Water-tube Boilers," by Prof. W. H. Watkinson.

(10) "The Non-uniform Rolling of Ships," by R. E. Froude, F.R.S.

(11) "A New Theory of the Pitching Motion of Ships on Waves, and of the Stresses produced by this Motion," by Captain A. Kriloff, Professor at the Naval Academy of St. Petersburg.

(12) "Notes on the Carriage of Grain Cargoes," by George Herbert Little.

The paper by Lord Charles Beresford set forth the views of a naval officer on the question of watertight doors. It may be said generally that the piercing of bulkheads has been done at the request, or perhaps more correctly speaking, the insistence of naval officers, who have found it difficult to work their ships with partitions in them not allowing means of ingress and egress from one compartment to the other. Lord Charles Beresford, however, differs from the majority of naval captains, and considers that bulkheads are too much pierced. He would do away with a large number of openings in a ship. He tells us that in the *Magnificent* and *Majestic*, which are the most powerful battleships in the service, and, therefore, in the world, there are 150 compartments in each ship, and 208 doors. Many of these of course are not in positions which are of vital importance, so far as flooding of the ship would be concerned in case of accident. He proposes to do away with nineteen of these doors in the most important part of the ship, and twenty-three would be made smaller, or modified so as to give additional safety in accordance with his proposals. This would undoubtedly add to the safety of the ship, and equally without doubt it would detract from the convenience of those inhabiting it. The latter may seem at first a small matter, but, as was pointed out during the discussion which followed the reading of the paper, convenience is to a large extent a measure of efficiency in action. In fighting a ship it is necessary for the men to move from part to part with great rapidity. This naturally means openings in bulkheads; for if a man, say the chief engineer, in order to get from one part of the vessel to another, has to climb up on deck to surmount a bulkhead, and descend on the other side, time will be occupied in the transition. In the rapid handling of ammunition, also, it is absolutely necessary that direct access should be obtained to various compartments; whilst for bringing coal from the bunkers to the stokehole floors, divisions must have openings made in them. It is also necessary to consider the question of habitability. A ship requires ventilation, otherwise it is impossible to live in her; at present a good deal of space is given to steam fans and air conduits, for this purpose. If bulkheads are to be unpierced, the difficulty of ventilation becomes more pronounced. It will be seen, therefore, that the question of openings in bulkheads, whether fitted with water-tight doors or not, is not of so simple a character as might at first appear. In fact in this element of warship design, as in all others, "compromise" must be the watchword. It is necessary not only for naval officers but for naval architects as well to meet and discuss this matter. Up to the present it has been rather that the naval officer has demanded watertight doors, and the ship designer, or naval architect, has opposed the demand. It is evident, from the discussion which followed the reading of Lord Charles Beresford's and Colonel Soliani's papers, that opinions are divided. It is essential that the matter should be threshed out, and the best compromise, according to our lights, should be adopted.

Colonel Soliani's paper dealt with different forms of watertight door. It was very fully illustrated, and will be a valuable source of reference to shipbuilders and naval architects.

In Mr. Bruhn's paper the question of stability of ships was treated, both in an historical and a mathematical manner. This contribution was read in brief abstract, and there was practically no discussion upon it. It is not one that would bear condensation very readily, and in any case could not be understood without the use of the diagrams which accompanied it. It dealt with the problem of constructing geometrically a set of cross curves of stability for inclinations from 90° to 180°, the corresponding curves from zero to 90° being known. Another section dealt with the determination of the direction in which the centre of buoyancy moves when a ship is inclined in a given direction. Lines of curvature and geodetic lines as curves of buoyancy, relations between the surfaces of buoyancy and flotation, and an extension of Leclert's theorem were subjects also dealt with; whilst the paper concluded with a geometrical construction for finding the length n, or the radius of curvature of the curve of flotation, from the usual information given on metacentric diagrams.

Mr. Seaton's paper was an extremely interesting one, and will prove of great practical value to engineers. As is well-known, the author is the managing director of Earle's Shipbuilding and Engineering Works at Hull. Some time ago part of the shafting of a screw steamer with which he had to do suddenly gave way. This shaft was made of steel containing from 0·2 per cent. to 0·25 per cent. of carbon, and its ultimate tensile strength was guaranteed to be not more than 30 tons, with an elongation of 25 per cent. in 5 inches. Mr. Seaton determined to make an inquiry into the composition of this shaft, and for that purpose it was subjected to chemical analysis. We need not repeat this analysis; it will be sufficient to state that it showed a very high proportion of undesirable elements in the steel. The most interesting part of the investigation was that carried out by Prof. J. O. Arnold, of Sheffield, who prepared micro-sections in the usual way. The chief point of the paper consists in the fact that chemical analysis is shown to be insufficient to give the engineer information as to the value of a given steel used for structural purposes. For instance, sulphur which is objectionable under certain conditions may be present to a considerable extent in a steel casting or forging, but though it may be of no serious moment if in one form, will be conducive to most disastrous results in another form. The chemist, as Mr. Seaton pointed out, is only able to state the quantity of sulphur present; but whether in a dangerous or non-dangerous form, he is unable to say. Mr. Seaton concludes, therefore, that chemical analysis alone is sufficient neither for steel nor for any other combined metal used by the engineer; while, on the other hand, the microscope reveals the actual structure of the material, and shows most distinctly whether it is a safe or an unsafe one. It appears, therefore, that the use of the microscope is likely to be of the utmost advantage to the marine engineer. We have not space to give the details by which Mr. Seaton supports his contention. The subject, however, is one well worthy of attention on the part of engineers, and scientific experts who work for them.

Mr. Stromeyer's paper was also one of interest. He proposes to measure the quantity of water either fed into a boiler, or passing through the condenser, by chemical means. A measured quantity of salt water is slowly injected, say into the condenser of an engine while at work; subsequently a chemical analysis for salt is carried out, both on a sample of sea-water and on a sample of the water to be measured. Their relative salinities would then give the quantity of water pumped, or the amount of steam condensed for any given period. The method is one which will probably be useful for estimating the quantity of circulating water used by the marine engineer, as it is capable of being applied to large quantities of flowing water with comparative facility. For the smaller volumes of water used for feed, which can be passed through pipes of moderate dimensions, the water-metre would, we think, be preferred by the majority of engineers; although, perhaps, the measuring-tank would command the greater confidence than either.

Mr. Kinghorn's paper, on salvage appliances, was of considerable practical interest. It referred to a new system of wreck-raising which has been evolved by certain salvage agents and marine engineers of Liverpool. This country is lamentably deficient in wreck-raising facilities, a fact which has been proved by the resource that has been had to foreign "wrecking" companies, when vessels of exceptionally large size have had to be raised. The case of the battleship *Howe*, at Ferrol, which was lifted by a Scandinavian company, and of the Atlantic liner *Eider*, wrecked on our own coast, and lifted by the same company, are instances in point.

The only evening sitting of the meeting, which was held on Thursday, the 26th ult., was devoted to the great water-tube boiler question, which is now agitating the marine engineering world. Of the three papers set down for reading, that of Prof. Watkinson was by far the most important. Colonel Soliani proposed a combination of fire-tube and water-tube boiler, which did not meet with universal approval during the discussion. Mr. Watt described certain experiments that he had made many years ago, and which could hardly be described as crucial. Prof. Watkinson attacked the great problem of circulation, the vital question certainly in water-tube boilers, and also to a far greater extent than has been supposed, in boilers of the shell, or fire-tube class. The circulation of water and steam in a water-tube boiler involves some very nice questions in physics. Its study affords a good opportunity for those highly skilled in physical science to assist the engineer in arriving at definite conclusions as to what causes govern the flow of water and steam in pipes subjected to heat. There were three types of boiler chiefly dealt with by Prof. Watkinson. The Belleville boiler, a French invention, which has now been in use for a number of years. It consists of a series of pipes of comparatively large diameter, say four inches to five inches; these are arranged in a continuous zigzag form, and subjected to the heat of the furnace; the water flows upward through this serpentine course, steam being generated in its course, and that water which is not converted into steam flows down external pipes, and then again passes into the bottom of the steam-generating pipes. In this way a continuous circulation is kept up. The distance the water has to travel through, from one end of the serpentine to the other, is considerable. The various lengths of pipe are not much inclined from the horizontal, and the sudden bends at the ends of each pipe tend to check the flow. It is believed that for this reason the Belleville boiler will not stand forcing—that is to say, only moderate quantities of coal can be burned to each unit of grate surface. For if rapid evaporation be attempted, the tubes are apt to be denuded of water. Judging by the recent trials of H.M.S. *Sharpshooter*, there would appear to be some truth in this contention. How far it applies, however, is a matter which experiment alone can reveal, and the results of such experiments, even if made, are not yet available so far as we are aware.

The other two kinds of boiler dealt with were of what is known as the "express" type—that is to say, they are boilers which will bear forcing, so that large quantities of fuel can be burned in a given time, and the rate of evaporation thus made very high. These are the well-known Thornycroft and Yarrow types of boiler, which have been so successfully applied to the torpedo-boat destroyers, which have given such remarkable results of late, in the matter of quick steaming. Although both the Yarrow and Thornycroft boiler have small tubes, say about one inch in diameter, which are comparatively short in length, each tube connecting directly with the top and bottom vessel, yet the two types have fundamental points of difference. The Thornycroft boiler has outside down-comers and bent tubes which discharge into the top drum above water. The Yarrow boiler has straight "drowned" tubes. These expressions require some further explanation. Each boiler consists essentially of a top drum or steam vessel, and two bottom drums or wing cylinders. Looked at in sectional elevation, these three drums form the points of a triangle standing on its base. The sides of the triangle are composed of the steam-generating tubes; the base is composed of the fire-grate. The products of combustion ascend from the grate amongst the tubes, and pass off to the furnace. In the Thornycroft boiler the outline formed by the three cylindrical vessels, and the connecting steam-generating tubes, is not strictly triangular, as the tubes are bent, as already stated. This bending enables them to be inserted into the top drum above the water-level carried into the latter. In the Yarrow boiler, the straight tubes pass in a direct line from the bottom vessels to the top drum, and therefore enter the bottom part of the latter, and, consequently, are below the water-level.

We will first trace the course of circulation of water in the Yarrow boiler. As there are several rows of tubes on each side of the furnace, those on the inside are naturally subjected to the greater heat. In them, as steam is first generated, the bubbles of steam rise, and water flows with them. To make up the deficiency thus caused in the content of the tube, water flows down the back tubes furthest from the fire, into the bottom vessel, which is common to all tubes on that side of the furnace, and then ascends those tubes where steam has been generated. In this way a continuous circulation is kept up. In the Thornycroft boiler this cycle cannot exist, as the tubes deliver above water, therefore special down-comer tubes have to be fitted; these enter the top drum below the water-level. Circulation takes place as follows. When the hot gases ascend among the bent steam-generating tubes, steam is generated. The tubes being small, it forces upward a certain quantity of water, which then falls into the top drum, and flowing down the downcomers, is able to rise again in the generating tubes to make up the deficiency. Circulation is, of course, due to the difference in specific gravity of the upward and downward columns of water in the generating tubes, and the down-comers, respectively. For some time past controversy has ranged between two schools—one favouring drowned tubes and anti-down-comers, the other undrowned tubes and down-comers, each maintaining that boilers constructed according to their views have most efficient circulation. Prof. Watkinson's paper dealt with this question, but no final opinion was expressed as to the respective values of the two types of boiler. The Professor had brought from Glasgow the glass model boilers with which he had made a number of experiments. Unfortunately, when he attempted to repeat these at the meeting, the breakage of tubes prevented him from carrying out his full programme. This is much to be regretted, as the experiments are of a very interesting nature. It is to be hoped that at no distant date Prof. Watkinson will have an opportunity of repeating them.

The last day of the meeting was devoted to two papers on pitching and rolling of ships. Mr. Froude's paper was practically a reply to one recently contributed by M. Émile Bertin, the eminent French naval architect, at the last meeting of the Institution; which in turn was a continuation of a paper by the said author read at a previous meeting. Without referring at length to these two papers it would be useless to attempt to give the substance of Mr. Froude's contribution, even if we had space to do so. It may be said, however, that Mr. Froude does not agree generally with M. Bertin. What the points of disagreement are, it would be impossible to explain without the aid of many diagrams, upon which the author relied for making his explanation clear. We must therefore refer our readers to the

Transactions of the Institution for information upon this intricate but extremely interesting subject.

Captain Kriloff's paper was of a completely mathematical character, and indeed was of far too abstruse a nature to follow during the reading. It depended on an appendix of many pages containing columns of figures which would require carefu study to master.

Mr. Little's paper was of practical interest to those concerned in the carriage of grain.

The proceedings were brought to a close by the usual votes of thanks.

The summer meeting this year is to be held in Hamburg during the early part of June. Extensive preparations have been made for the reception of members, and there is no doubt the meeting will be of quite an international character. The success of last year's meeting in Paris has encouraged the Council to go abroad again.

It may be added that the Institution is increasing in numbers at a rapid rate, there being a greater addition to the roll of membership at this meeting than has ever before taken place.

RECENT WORK WITH RÖNTGEN RAYS.

SEVERAL important communications referring to work upon Röntgen rays have come before our notice during the past week. While some experimenters are perfecting the methods so as to develop the capabilities of the rays, others are investigating the physical characteristics pertaining to them, and in both directions of work clear advances have been made since our last eclectic statement of the contributions to the subject founded by Röntgen's discovery.

Prof. Alfred M. Mayer, of the Stevens Institute of Technology, has sent us the following account of experiments carried out by him on the polarisation of Röntgen rays.

"Of the remarkable properties of the Röntgen rays, the one of the greatest interest is that these rays are not polarisable; for this property shows that these rays, unlike those of light, are not propagated by vibrations transverse to the direction of their progress. To decide conclusively this point certain properties, shown by Röntgen's experiments, must be possessed by the substance which is to act on the Röntgen rays, viz. (1) a low density; (2) the substance must be very thin, and yet give complete polarisation to transmitted light. These two properties are eminently peculiar to herapathite, an iodo-sulphate of quinine. Its density is only 1·8, and crystals of herapathite of only 0·05 mm. in thickness, with their axes crossed at 90°, entirely obstruct the incident light, so that their crossed portions appear intensely black.

"Six discs of glass, 0·15 mm. thick and 25 mm. in diameter, were covered with crystal-plates of herapathite crossing one another at various angles. Where they crossed at right angles they gave a black field. These discs were fastened to the surface of a screen of compressed brown paper, which was found to be impervious to the actinic action of a powerful arc light acting during two hours, and placed 1 foot in front of the screen; the latter covering a sensitive photographic plate. On this screen were also placed three discs of the same glass, overlapping one another, so that 1, 2, and 3 thicknesses of the glass had to be traversed by the X-rays before they reached the photographic plate. These discs served as standards with which to compare the action of the X-rays on the discs covered with herapathite. On the same screen was also placed a square of yellow blotting-paper, $\frac{3}{4}$ mm. in thickness, having on its surface superposed herapathite crystals from two to four layers deep.

"This screen so prepared, and covering a sensitive plate, was exposed to the radiations of the Crookes' tube; in the first experiment for half an hour, in the second for one hour, and in the third for two and a half hours. On developing these plates there was not the slightest trace of the presence of the herapathites. The photographs of the glass discs had not the slightest mottling on their surfaces. Their surfaces appeared throughout to the unaided eye, and also when examined with a magnifying glass, with a uniform illumination and grain throughout. The herapathite, of the thickness used in these experiments, does not appear to screen at all the X-rays; for all the discs carrying it appeared exactly alike, in illumination and in grain, to the photograph of a similar disc having nothing on its surface. But the action of the rays on the square of blotting-paper carrying the herapathites showed this in a more conclusive manner; for where this paper covered the photographic plate nothing was visible, except by the most careful scrutiny, and with the most favourable illumination, and then a mere ghost of the paper could be detected, but with no traces whatever of the herapathites.

"These experiments appear to have shown conclusively what Röntgen found by his experiments; viz. that the X-rays are not polarised by passing through doubly-refracting media."

At a recent meeting (March 3) of the Dublin University Experimental Science Association, Dr. J. Joly, F.R.S., described experiments made by him on the "Lenard-Röntgen" rays. He has found that the rays are reflected at the surface of mercury, lead, glass and wood. A photographic plate was enclosed in a light-tight carrier of millboard, upon the outside of which a copper ring was attached. This was exposed in the geometrical shadow of a thick lead plate to rays which entering a slot in the plate were reflected at the surface of mercury. An exposure of over an hour gave the shadowgraph of the ring. The position of this upon the plate indicated that the rays had approached from the direction of the reflecting mercury surface. Removing the dish of mercury, a much fainter image was obtained apparently from rays reflected from the wood beneath.

If the rays are received upon the carrier after passage between two parallel lead plates, the dark band formed upon the sensitive plate will be found to be bordered by heavy black lines. This was traced to a very complete reflection at grazing incidence to the lead plates, corresponding to the manner in which light is reflected at grazing incidence. A photographic plate exposed to light passing between the lead plates shows, in fact, a similar dark border; substituting glass plates for the lead, similar effects were obtained. This marked grazing reflection rendered it possible to concentrate the rays to an imperfect focus by causing them to pass through a conical tube of lead open at both ends, when a strengthening of the effects was formed on exposing at the narrow end of the cone.

Before the Royal Society on March 19, Lord Blythswood described some experiments which indicate that the X-rays can be reflected. He placed a vacuum-tube, A (Figs. 1-2), behind a lead screen, B B, 18 in. × 12 and $\frac{1}{8}$ thick. The screen had a 2-in. hole in it with a 2-in. pipe attached; 4 in. from the vacuum-tube was placed a speculum-metal mirror D, 4 in. × $2\frac{1}{2}$, at an angle of 45° with the lead screen; 4 in. from the mirror was a light-tight zinc box, E, with aluminium window, F; inside came first the objects, G, stuck on to a black cardboard, H, then I, the photographic plate. The following objects were photographed in about twenty minutes: (1) Some brass clock wheels. (2) A screw-cutting gauge. (3) Two lead discs. (4) The mirrors, being two pieces of speculum-metal used by Lord Blythswood to divide upon.

Two other papers were read before the Royal Society at the same meeting. In one of these, Mr. R. Erskine Murray described experiments made in the Cavendish Laboratory of the University of Cambridge, at Prof. J. J. Thomson's suggestion, in order to find whether the contact potential of a pair of plates of different metals is in any way affected by the passage of the Röntgen X-rays between the plates.

The vacuum bulb and induction coil for the production of the rays were enclosed in a box lined with metal, so that the plates and the apparatus used in measuring their contact potential difference should be screened from any direct electrical disturbances. At one side of the box there was a circular hole of about 3 cm. in diameter. The vacuum bulb was placed just inside this hole, and directed so that the rays should stream out through it in a direction perpendicular to the side of the box. In some experiments this hole was closed by a tinfoil screen, which allowed a large proportion of the rays to pass out while shutting in ordinary electrical disturbances. The plates whose contact potential difference was to be measured were placed at a short distance outside the box, in such a position that the rays could fall on them.

To measure their contact potential, Mr. Murray used the null method described by Lord Kelvin in his paper given to the British Association in 1880. In this method the value of the contact potential is found by measuring the amount of the counter potential which has to be applied to the pair of plates to reduce the potential difference between their opposing surfaces to zero. The counter potential introduced to effect this annulment must obviously be equal and opposite to their contact potential difference. Hence the numerical value of the latter is simply