in the western suburbs of London, and perhaps also in other parts. Two remedies are recommended for warding off the insects; one by scattering amongst the plants some pulverised gas-lime, and the other by watering with the liquid from pig-sties. The clouded yellow butterfly (*Colias edusa*) was, it seems, "the great appearance of the year," and was first seen near Dumfries early in June, and across the south of England it was generally observable from June till October. The frequent death of the larvæ when feeding on various clovers and trefoils is mentioned as a point of interest relatively to its permanent settlement, as also the great difference in the quantity of the sexes noticed at various stations which may be followed by coincident variety of appearance next year. The report is published by Mr. T. P. Newman, Botolph Lane, Eastcheap, from whom we believe copies may be obtained. Every information on the subject will also be supplied on application to the Rev. T. A. Preston, The Green, Marlborough, Wilts, E. A. Fitch, Esq., Maldon, Essex, or Miss E. A. Ormerod, Dunster Lodge, Spring Grove, Isleworth.

The St. Petersburg University has addressed a note to the Ministry of Public Instruction requesting that the necessary steps be taken for the preservation of any valuable manuscripts which may be found in the Turkish towns occupied by Russian troops. Valuable manuscripts were preserved in this way from destruction in the War of 1829, and important manuscripts have already been discovered in the mosques of Tirnova.

A small Japanese "blue" book comes to us in the shape of a report by the department of Public Hygiene on some of the mineral waters of the country and the uses to which they may be put. Japan seems to contain a great variety of such waters.

At the meeting of the Musical Association on February 4 a paper was read by Mr. D. J. Blaikley, "respecting a Point in the Theory of Brass Instruments." The necessary difference in form between such instruments and conical tubes was pointed out, and a new experimental method for determining the positions of the nodal points in tubes, especially applicable to such as are of varying section, was shown. As an instance may be given a conical tube open at both ends and of the pitch C 512 vib. The node is nearer the small than the large end of the tube, and by sinking one end in water and holding a fork of the pitch of the tube over the other, the exact position of the node is shown by the level of the water when the tube is giving its maximum resonance.

The additions to the Zoological Society's Gardens during the past week include two Macaque Monkeys (*Macacus cynomolgus*) from India, presented by Lieut-Col. Fielden; a Grivet Monkey (*Cercopithecus griseo-viridis*) from North-east Africa, presented by Mr. E. H. Lockley; a Garden's Night Heron (*Nycticorax gardeni*) from South America, presented by Mr. Henry Bottrell; three Chimpanzees (*Troglodytes niger*) from West Africa, deposited; a Black-faced Spider Monkey (*Ateles ater*) from East Peru, a Collared Peccary (*Dicotyles tajaçu*) from South America, a Globose Curassow (*Crax globicera*) from Central America, a Black-footed Penguin (*Spheniscus demersus*) from West Africa, a Hey's Partridge (*Caccabis heyi*) from Arabia, purchased.

ON COMPASS ADJUSTMENT IN IRON SHIPS[1]

I.—*New Form of Marine Azimuth and Steering Compass with Adjuncts for the complete Application of the Astronomer-Royal's Principles of Correction for Iron Ships.*

Thirty-eight years ago the Astronomer-Royal showed how the errors of the compass, depending on the influence experienced from the iron of the ship, may be perfectly corrected by magnets and soft iron placed in the neighbourhood of the binnacle. Partial applications of his method came into immediate use in merchant steamers, and within the last ten years have become universal not only in the merchant service, but in the navies of this and other countries. The compass and the binnacles before you are designed to thoroughly carry out in practical navigation the Astronomer-Royal's principles. The general drawback to the complete and accurate realisation of plans for carrying out these principles heretofore, has been the great size of the needles in the ordinary compass which renders one important part of the correction, the correction of the quadrantal error for all latitudes by masses of soft iron placed on the two sides of the binnacle, practically unattainable; and which limits, and sometimes partially vitiates, the other chief part of the correction, or that which is performed by means of magnets placed in the neighbourhood of the compass. Five years ago my attention was forced to this subject through my having been called upon by the Royal Society to write a biographical sketch of the late Archibald Smith, with an account of his scientific work on the mariner's compass and ships' magnetism, and I therefore commenced to make trial compasses with much smaller needles than any previously in use; but it was only after three years of very varied trials, in the laboratory and workshop, and at sea, that I succeeded in producing a mariner's compass with the qualities necessary for thoroughly satisfactory working in all weathers and all seas, and in every class of ship, and yet with small enough needles for the perfect application of the Astronomer-Royal's method of correction for iron ships. One result at which I arrived, partly by lengthened trials at sea in my own yacht, and partly by dynamical theory analogous to that of Froude with reference to the rolling of ships, was that steadiness of the compass at sea was to be obtained not by heaviness of needles or of compass-card, or of added weights, but by longness of vibrational period[1] of the compass, however this longness is obtained. Thus, if the addition of weight to the compass-card improves it in respect to steadiness at sea, it is not because of the additional friction on the bearing-point that this improvement is obtained; on the contrary, dulness of the bearing-point, or too much weight upon it, renders the compass less steady at sea, and, at the same time, less decided in showing changes of the ship's head, than it would be were the point perfectly fine and frictionless, supposing for the moment this to be possible. It is by increasing the vibrational period that the addition of weight gives steadiness to the compass; while, on the other hand, the increase of friction on the bearing-point is both injurious in respect to steadiness, and detrimental in blunting it or breaking it down, and boring into the cap, and so producing sluggishness, after a short time of use, at sea. If weight were to be added to produce steadiness, the place to add it would be at the very circumference of the card. My conclusion was that no weight is in any case to be added, beyond that which is necessary for supporting the card; and that, with small enough needles to admit of the complete application of the Astronomer-Royal's principles of correction, the length of period required for steadiness at sea is to be obtained, without sacrificing freedom from frictional error, by giving a large diameter to the compass-card, and by throwing to its outer edge as nearly as possible the whole mass of rigid material which it must have to support it.

In the compass before you (Fig. 1), these qualities are given by supporting the outer edge of a card on a thin rim of aluminium, and its inner parts on thirty-two silk threads or fine copper wires stretched from the rim to a small central boss of aluminium, thirty-two spokes, as it were, of the wheel. The card itself is of thin strong paper, and all the central parts of it are cut away, leaving only enough of it to show conveniently the points and degree-divisions of the compass. The central boss consists of a thin disc of aluminium, with a hole in its centre, which rests on the projecting lip of a small aluminium inverted cup mounted with a sapphire cap, which rests on a fixed iridium point (Figs. 2 and 3).

Eight small needles from $3\frac{1}{4}$ inches to 2 inches long, made of thin steel wire, and weighing in all fifty-four grains, are fixed like the steps of a rope ladder on two parallel silk threads, and slung from the aluminium rim by four silk threads or fine copper wires through eyes in the four ends of the outer pair of needles.

The weight of the central boss, aluminium cup, and sapphire

[1] Report of paper read to the Royal United Service Institution, February 4, by Sir Wm. Thomson, LL.D., F.R.S., P.R.S.E., Professor of Natural Philosophy in the University of Glasgow, and Fellow of St. Peter's College, Cambridge. Revised by the Author. [The Council of the U.S.I. have kindly permitted us to publish Sir W. Thomson's paper in advance, and have granted us the use of the illustrations.—Ed.]

[1] The vibrational period, or the period (as it may be called for brevity) of a compass, is the time it takes to perform a complete vibration, to and fro, when deflected horizontally through any angle not exceeding 30° or 40°, and left to itself to vibrate freely.

cap, amounts in all to about five grains. It need not be more for a 24-inch than for a 10-inch compass. For the 10-inch compass the whole weight on the iridium point, including rim, card, silk threads, central boss, and needles, is about 180 grains. The limit to the diameter of the card depends upon the quantity of soft iron that can be introduced without inconvenient cumbrousness on the two sides of the binnacle to correct the quad-

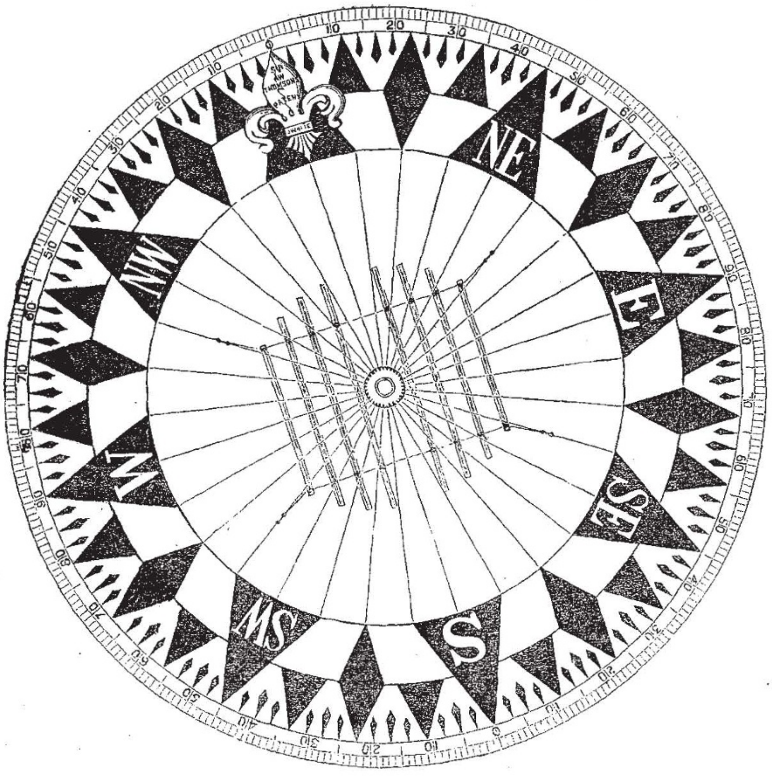

FIG. 1.

rantal error. If, as sometimes may be advisable in the case of a pole or masthead compass, it be determined to leave the quadrantal error uncorrected, the diameter of the compass-card may be anything from 12 to 24 inches, according to circumstances. A 24-inch card on the new plan will undoubtedly have less frictional error or "sluggishness" for the same degree of steadiness

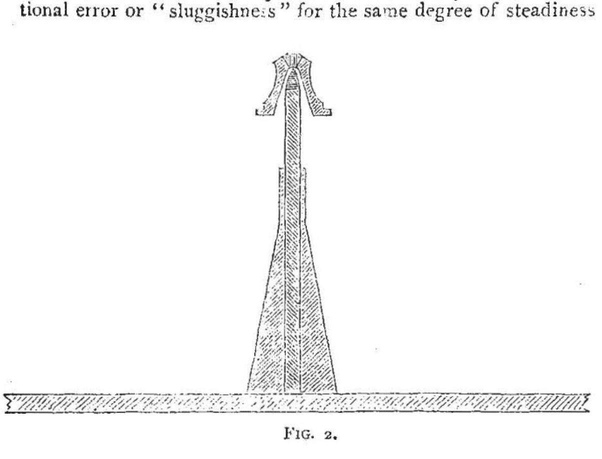

FIG. 2.

than any smaller size; but a 12-inch card works well even in very unfavourable circumstances, and it will rarely, if ever, be necessary to choose a larger size unless for convenience to the steersman for seeing the divisions, whether points or degrees. You see hanging over the table, from the roof, one of my 12-inch pole-compasses. Specimens of 15-inch and 24-inch pole-compasses have also been made. The last-mentioned may be looked at with some curiosity, as being probably the largest compass in the world. It will no doubt be properly condemned as too cumbrous for use at sea, even in the largest ship, but there can be no doubt it would work well in a position in which a smaller compass would be caused to oscillate very wildly by the motion of the ship. The period of the new 10-inch compass is in this part of the world about forty seconds, which is more than double the period of the A card of the Admiralty standard compass, and is considerably longer than that of the ordinary 10-inch compass, so much in use in merchant steamers. The new compass ought, therefore, according to theory, to be considerably steadier in a heavy sea than either the Admiralty compass or the ordinary 10-inch compass, and actual experience at sea has thoroughly fulfilled this promise. It has also proved very satisfactory in respect to frictional error; so much so that variations of a steamer's course of less than half a degree are shown instantly and surely, even if the engine be stopped, and the water perfectly smooth.

With the small needles of the new compass, the complete practical application of the Astronomer-Royal's principles of correction is easy and sure: that is to say, correctors can be applied so that the compass shall point correctly on all points, and these correctors can be easily and surely adjusted at sea, from time to time, so as to correct the smallest discoverable error growing up, whether through change of the ship's magnetism, or of the magnetism induced by the earth, according to the changing position of the ship. To correct the quadrantal error I use a pair of solid or hollow iron globes placed on proper supports, attached to the binnacle on two sides of the compass. This mode is preferable to the usual chain boxes, because a continuous globe or spherical shell of iron is more regular in its effect than a heap of chain, and because a considerably less bulk of the continuous iron suffices to correct the same error. When in a first adjustment in a new ship, or in a new position of a compass in an old ship, the quadrantal

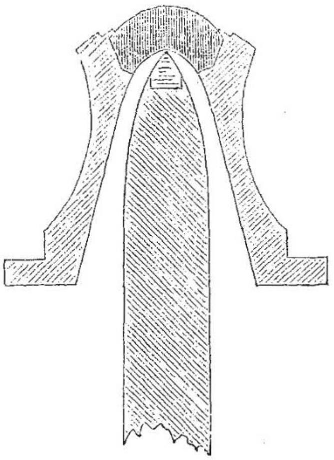

FIG. 3.

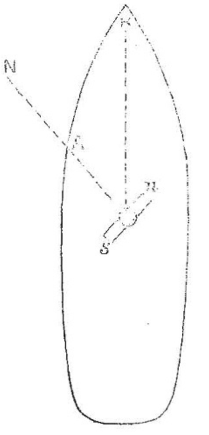

FIG. 4.

error has been found from observation, by the ordinary practical methods, it is to be corrected by placing a pair of globes in proper positions according to the following table:—

Table for Correction of Quadrantal Error.

Error to be Corrected.	Distances of the Nearest Points of Globes from Centre of Compass.									
	9-inch globes.	8½-inch globes.	8-inch globes.	7½-inch globes.	7-inch globes.	6½-inch globes.	6-inch globes.	5½-inch globes.	5-inch globes.	4½-inch globes.
°	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1	20·52	19·38	18·24	17·10	15·96	14·82	13·68	12·54	11·40	10·26
1½	17·36	16·39	15·42	14·46	13·50	12·54	11·57	10·61	9·65	8·68
2	15·36	14·51	13·66	12·81	11·95	11·10	10·24	9·39	8·53	7·68
2½	13·94	13·16	12·39	11·61	10·84	10·07	9·29	8·52	7·74	6·97
3	12·84	12·13	11·42	10·70	9·99	9·28	8·57	7·85	7·14	5·42
3½	11·98	11·32	10·65	9·99	9·32	8·65	7·99	7·32	6·66	5·99
4	11·26	10·63	10·01	9·39	8·76	8·13	7·51	6·88	6·26	5·63
4½	10·66	10·07	9·47	8·88	8·29	7·70	7·10	6·51	5·92	5·33
5	10·13	9·57	9·01	8·45	7·88	7·32	6·75	6·19	5·63	5·07
5½	9·67	9·13	8·59	8·06	7·52	6·99	6·45	5·91	5·38	4·84
6	9·27	8·75	8·24	7·72	7·21	6·70	6·18	5·66	5·15	4·53
6½	8·91	8·41	7·92	7·42	6·93	6·44	5·94	5·44	4·95	4·46
7	8·58	8·10	7·63	7·15	6·67	6·20	5·72	5·24	4·77	4·29
7½	8·28	7·82	7·36	6·90	6·44	5·98	5·52	5·06	4·60	4·14
8	8·01	7·57	7·12	6·68	6·23	5·79	5·34	4·90	4·45	4·01
8½	7·76	7·33	6·90	6·47	6·04	5·60	5·17	4·74	4·31	3·88
9	7·53	7·11	6·69	6·27	5·86	5·44	5·02	4·60	4·18	3·76
9½	7·32	6·91	6·50	6·09	5·69	5·28	4·87	4·47	4·06	3·66
10	7·11	6·72	6·32	5·93	5·53	5·14	4·74	4·35	3·95	3·55
10½	6·93	6·54	6·16	5·77	5·39	5·00	4·62	4·23	3·85	3·46
11	6·75	6·37	6·00	5·62	5·25	4·87	4·50	4·12	3·75	3·37
11½	6·58	6·22	5·85	5·49	5·12	4·76	4·39	4·02	3·66	3·29
12	6·43	6·07	5·71	5·36	5·00	4·64	4·29	3·93	3·57	3·22

When the quadrantal error has been thus once accurately corrected, the correction is perfect to whatever part of the world the ship may go, and requires no adjustment at any subsequent time, except in the case of some change in the ship's iron, or of iron cargo or ballast sufficiently near the compass to introduce a sensible change in the quadrantal error. The vast simplification of the deviations of the compass effected by a perfect correction of this part of the whole error has not, as yet, been practically appreciated, because, in point of fact, this correction had rarely, if ever, in practice, been successfully made for all latitudes. The pair of large needles of the compass ordinarily used in merchant ships does not, as has been shown by Capt. Evans and Archibald Smith, admit of the correction of the quadrantal error in the usual manner, without the introduction of a still more pernicious error, depending on the nearness of the ends of the needles to the masses of chain, or of soft iron of whatever kind, applied on the two sides of the compass to produce the correction. The Admiralty standard compass, with its four needles proportioned and placed according to Archibald Smith's rule, is comparatively free from this fault: but even with it, and still more with the stronger magnets of the larger compasses of merchant ships, there is another serious cause of failure depending on the magnetism induced in the iron correctors by the compass needles, in consequence of which, if the quadrantal error is accurately corrected in one latitude, it will be found over-corrected in high magnetic latitudes, and under-corrected in the neighbourhood of the magnetic equator. The new compass was specially designed to avoid both these causes of failure in the correction of the quadrantal error; and experiment has shown that with it the correction by such moderate masses of iron as those indicated in the preceding table, is practically perfect not only in the place of adjustment, but in all latitudes.

When once the quadrantal error has been accurately corrected, the complete application of the Astronomer-Royal's principles becomes easy and sure, if the binnacle is provided with proper appliances for readjusting the magnetic correctors from time to time, whether at sea or in port. But the system of nailing magnets to the deck, in almost universal use in the merchant service, is not satisfactory, and is often even dangerous. It always renders needlessly tedious and cumbrous the process of readjustment by the adjuster in port, and it leaves the captain of the ship practically no other method of readjustment at sea than removing the magnets altogether, or taking them out of their cases and replacing them in inverted positions. The Astronomer-Royal himself pointed out that his correcting magnets should be mounted in such a manner that their distances from the compass can be gradually changed, so as always to balance the ship's magnetic force as it alters, whether by gradual loss of her original magnetism through lapse of time, or by the inductive influence of the earth's vertical magnetic force coming to zero, and then becoming reversed in direction when a ship makes a voyage from the northern to the southern hemisphere. The not carrying out of this essential part of his plan, whether through no method or no sufficiently convenient method of adjustment having been hitherto provided, has undoubtedly taken away much of the credit among many practical men to which the Astronomer-Royal's method is justly entitled. I have, therefore, introduced into the binnacles provided for my compass, when it is to be used in iron ships, a complete system of adjustable correctors for perfectly correcting the error of the compass for every position of the ship's head when she is on even keel, and a vertical adjustable magnet below the compass, for correcting the heeling error (more properly speaking, a magnet, which is vertical when the ship is on even keel, and which shares the inclination of the ship when she heels over to either side).

An objection which has often been made to the use of correctors at all, and particularly to the use of correctors for a standard compass, is that they conceal the actual state of the ship's magnetism, and that readjustment of the correctors at sea leaves the navigator without means of judging, when he returns from a foreign voyage, how much of the changed error found on readjustment in port depends on changes which have been made in the correcting magnets, and how much on changes of the ship's own magnetism. This objection I meet by providing that at any moment my correctors can be removed or set to any degrees of power to which they may have been set at any time in the course of the voyage, and again reset to their last position with perfect accuracy. The appliances for changing the adjustment are under lock and key, so that they can never be altered, except by the captain or some properly authorised officer. Farther, to facilitate the use of the correctors, I graduate the scales accurately to correspond to definite variations of the force which they produce on the compass. Thus, as soon as the error has been determined by the known method of observation at sea, the corrector may at once be altered to the proper degree to correct it. Of course the officer performing the adjustment will satisfy himself of its correctness by a second observation. The objection of "delicacy of manipulation," and the difficulty of carrying it out, except by a professional adjuster, of which so much has been said, is entirely done away with when adjustable correctors, with scales thus accurately graduated, are provided with the binnacle.

The binnacles before you are of two kinds adapted to the two different methods given by the Astronomer-Royal for correcting the semi-circular part of the error; one, the square one, for correcting, by two sets of magnets, fore-and-aft and thwart-ship respectively; the other, the round one, for correcting by a single magnet, or group of bars equivalent to a single magnet, placed under the centre of the compass with its magnetic axis in the proper direction to balance the whole disturbing force on the compass due to that part of the ship's magnetism which is unchanged when she is put on different courses in the same magnetic latitude. The two sets of instructions, in the two printed pamphlets before you, explain sufficiently, for the two binnacles, the arrangements of the magnetic correctors in the two cases, and how to use them in practice.

The principle in each case is easily understood. In the system employed in the square binnacle the whole constant force, due to the part of the ship's magnetism which remains constant when the ship is put on different courses, is regarded as being replaced by three constant "component" forces in the direction of three lines, at right angles to one another—one fore-and-aft, one thwart-ship, and the third perpendicular to the deck. The fore-and-aft component is balanced by the fore-and-aft correcting magnets, the thwart-ship component by the thwart-ship magnets, and the component perpendicular to the deck by the heeling corrector, which is a bar-magnet, adjustable to the proper height, in a line perpendicular to the deck, through the centre of the compass and of the binnacle.

In the round binnacle the component perpendicular to the deck is balanced by a heeling corrector, just as in the square one; but, instead of considering separately two components parallel to the deck, their resultant or the single component parallel to the deck, which, with the component perpendicular to the deck, constitutes the whole force, is balanced by a single magnetic force parallel to the deck. This force is obtained by turning the revolving corrector round the central axis of the binnacle, and raising it or lowering it until the proper direction and proper magnitude of force are produced.

One novel feature in the last binnacle is the way in which, by aid of the guide-ring graduated to logarithmic cosecants, and the vertical scale graduated to equal proportionate differences of force, the adjustment to correct the compass on one course may be performed without disturbing its accuracy on another course on which it has been previously adjusted. The principle of this arrangement is most easily explained by aid of the mathematical notation of trigonometry, in connection with the annexed diagram (Fig. 4), in which O represents the compass-card, A, a point of the ship which was in the direction of the correct magnetic north, N, at the time of the first supposed adjustment, ns, the position of the axis of the revolving corrector set to correct the compass on that course, H the ship's head. We have (according to the notation of the instructions)—

$$HOA = H,$$
$$nOH = C;$$
$$\text{therefore,}\quad nOA = H + C.$$

Now the correction on the first supposed course, if it did not annul the force due to the magnetism of the ship and correctors, reduced it to a force in the line OA. Hence the component perpendicular to OA due to the corrector must be kept unchanged in subsequent correction, so as not to disturb the adjustment for that first course. Let F be the magnitude of the force due to the revolving corrector. Its direction being On, its component perpendicular to OA is equal to $F \sin nOA$. Hence, if F be increased by raising, or diminished by lowering, the corrector, the angle nOA must be altered so that $\sin nOA$ shall vary inversely as F, or $\operatorname{cosec} nOA$ directly as F. In other words, $\frac{F}{\operatorname{cosec} nOA}$ must be kept constant, and, therefore, the difference between $\log F$ and $\log \operatorname{cosec} nOA$ must be kept constant. When the guide-ring is placed according to Rule 2, Section 4, of the Instructions, the reading upon it is the value of $\log\text{-}\operatorname{cosec}(H+C)$. The reading on the vertical scale is always proportional to the logarithm of F. Hence Rule 3 secures that the change of magnitude and direction of the correcting force does not vitiate the correction on the course H.

(*To be continued.*)

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

OXFORD.—An examination for the Burdett-Coutts Scholarship will be held in the University Museum, on Monday, March 11, and three following days, at 10 A.M., for the purpose of electing a scholar on that foundation. Candidates are requested to call on the Professor of Geology at 34, Broad Street, with certificates of their standing, and the consent of the head or vice-regent of their College or Hall, on Friday, March 8, between 4 and 5 P.M.

CAMBRIDGE.—The exhibition offered by the Clothworkers' Company, to non-collegiate students of the University, for proficiency in physical science, has been awarded to J. G. M'Cubbin, who was educated at the Manchester Grammar School. The exhibition is of the annual value of 50*l.*, and is tenable for three years. The next examination for a similar exhibition open to non-collegiate students who have not resided more than one term, or who have not commenced residence, will be held on July 15 and 17, in connection with the examination conducted by the Oxford and Cambridge Schools Examination Board. Intending candidates can obtain full information on application to the Rev. R. B. Somerset, censor of non-collegiate students, Cambridge.

GILCHRIST EDUCATIONAL TRUST.—A course of six Gilchrist Science Lectures for the People, will be delivered in the Bristol Athenæum, by members of the Council and Staff of University College, Bristol, as follows:—February 22, The Action of Heat, by S. P. Thompson, B.Sc., B.A.; March 5, Heat and the Steam Engine, by J. F. Main, B.A. Camb., D.Sc. Lond; March 12, The Ocean a Carrier of Heat, by W. L. Carpenter, B.A., B.Sc.; March 19, Heat within the Safety Lamp, by S. P. Thompson, B.Sc., B.A.; March 26, the Sun's Heat, by J. F. Main, B.A. Camb., D.Sc. Lond.; April 2, the Chemistry of Burning, by W. W. J. Nicol, M.A. The same course is to be given at Bath, Bridgwater, Trowbridge, and Newport (Monmouthshire).

THE BIRKBECK INSTITUTION.—The Lord Mayor has promised to preside at a meeting, to be held at the Mansion House on Wednesday afternoon, the 27th inst., at three o'clock, for the purpose of inaugurating a fund to provide the Birkbeck Institution with a building suitable to its large and important operations, and to enable it to take advantage of the many opportunities for further usefulness which are from time to time presented. As the Institution is doing such an important educational work amongst the young men and women of the metropolis, it is hoped that the friends of education will liberally assist the movement to accomplish so desirable an object. The number of students has been steadily increasing for some years past, and, notwithstanding alterations and extensions of the building, it is impossible any longer to accommodate those attending the Institution. Some indication of the work will be gained from the fact that 3,304 persons joined the Institution during the past term.

ST. PETERSBURG.—The professors of the High School of Medicine for Ladies at St. Petersburg, among whom are many names well known in science, have addressed a petition to the Minister of Public Instruction, in which they claim for ladies who have completed their studies at the high schools, the same degrees as for men. They support their request by pointing out that the five years' theoretical and practical study at the ladies' school are quite as extensive as those pursued by male students, and rather more extensive in the department of female diseases; that the monthly and yearly examinations have always proved that the ladies possess a very thorough knowledge of their subjects, and finally, that during their service with the army in Roumania and Bulgaria, the ladies have given numerous and sufficient proofs of their high capacity for acting as surgeons.

FREIBURG.—The university is attended at present by 334 students, including 41 in the theological faculty, 70 in the philosophical, 76 in the legal, and 147 in the medical. It possesses a library of 300,000 volumes, and well-equipped scientific laboratories and collections, but fails of late years to rank among the influential German universities, partly on account of the rivalry of its neighbours, Tübingen, Heidelberg, and Strasburg.

WÜRZBURG.—The corps of instructors numbers at present 40 ordinary professors, 5 extraordinary professors, and 17 privat docenten. The number of students, 947, shows a decrease of about 50 on the past half year. On January 2 the 296th anniversary of the foundation of the university was celebrated, and an address delivered by the rector, Prof. Risch, on the national importance of the German universities and their relations to the empire. In the course of the address the Imperial Government was sharply criticised for having, with the exception of the