THE additions to the Zoological Society's Gardens during the past week include a Guinea Baboon (*Cynocephalus sphinx*, ♂) from West Africa, presented by Captain H. de la Cour Travers; a Vervet Monkey (*Cercopithecus lalandii*, ♂) from South Africa, presented by Mr. C. J. Barratt; a Common Raccoon (*Procyon lotor*) from North America, presented by Mr. A. D. Jenkins; a Reindeer (*Rangifer tarandus*, ♂) from Newfoundland, presented by the Hon. M. A. Bourke, H.M.S. *Cordelia*; a Common Guillemot (*Lomvia troile*), British, presented by Mr. Ernest Horne; a Seven-banded Snake (*Tropidonotus septemvittatus*) from North America, presented by Mr. James Meldrum; a Barbary Ape (*Macacus innus*, ♂) from North Africa, a Red-River Hog (*Potamochœrus penicillatus*) from West Africa, a Beccari's Cassowary (*Casuarius beccarii*) from New Guinea, two Orange-winged Amazons (*Chrysotis amazonica*), two Blue-fronted Amazons (*Chrysotis æstiva*) from South America, deposited; a Leucoryx Antelope (*Oryx leucoryx*, ♂) from North Africa, purchased; a Red-winged Parrakeet (*Ptistes erythropterus*, ♀), a Long-billed Butcher-Crow (*Barita destructor*) from Australia, received in exchange; two Japanese Deer (*Cervus sika*, ♂ ♀), three Shaw's Gerbilles (*Gerbillus shawi*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OCCURRENCES IN JUNE:—

June 3. 6h. 34m. to 9h. 25m. Transit of Jupiter's Sat. III.
4. 8h. Eastern elongation of Saturn's Sat. Japetus.
4. 8h. 10m. to 9h 11m. Occultation of A Ophiuchi (mag. 4·7) by the moon.
4. 15h. 43m. to 16h. 34m. Occultation of B.A.C. 5909 (mag. 6·2) by the moon.
5. 10h. 15m. to 11h. 22m. Occultation of λ Sagittarii (mag. 3·1) by the moon.
9. 11h. 31m. to 12h. 23m. Occultation of B.A.C. 7804 (mag 6·1) by the moon.
9. Saturn. Outer minor axis of outer ring, 18″·62.
10. 10h. 23m. to 13h. 16m. Transit of Jupiter's Sat. III.
12. 19h. Neptune in conjunction with the sun.
15. Venus. Illuminated portion of disc 0·853.
15. Mars. ,, ,, ,, 0·919.
15. Jupiter. Polar diameter, 34″·8.
15. Saturn. ,, ,, 17″·0.
17. 9h. 45m. to 11h. 23m. Transit of Jupiter's Sat. IV.
18. 10h. 59m. Minimum of β Persei (Algol).
23. 5h. Inferior conjunction of Saturn's Sat. Japetus.
29. Saturn. Outer minor axis of outer ring, 18″·33.

The transit of Jupiter's fourth satellite on June 17 is the only one visible during 1898.

BLURRING ABERRATION IN THE TELESCOPE. — Some time ago we referred in this journal (December 30, 1897, p. 200) to a communication by Prof. Schæberle which pointed out that the optical image of a celestial object, formed in the focus of a reflecting telescope of great angular aperture, is possessed of errors of definition which arise from a cause hitherto unrecognised by mathematical and practical opticians. The main results of this paper briefly summed up are as follows:—First, that the focal plane of a curved reflecting surface for parallel rays impinging thereon is situated upon the axis, half-way between the centre of curvature and the reflecting surface itself; and, second, that the plane of the image formed by each small patch of the converging surface tends to lie at right angles to the path of the focussed rays, so that the images formed from every minute portion of the reflecting surface, while their centres may coincide on the axis of the telescope, all tilt from the focal plane directly as the extreme of aperture is approached, or as the focal point is shifted from the axis. In the *Transactions* of the Astronomical and Physical Society of Toronto for 1897, Mr. J. R. Collins, in referring to Prof. Schæberle's paper, points out that it is possible to so proportion the curvatures of the reflecting surfaces of the Gregorian form of reflecting telescope (where the image is formed by the large reflector in front of the small concave mirror, and the light is thrown back to a focus on the axis through an opening in the centre of the large reflector to the eye-piece), as to completely correct the tilt and want of uniformity of dimensions of the components of the compound image, that it may reach the front of the eye-piece entirely freed from these defects. It may be remarked that the tilting of the image not only occurs in the case of the reflector, but in that of the refractor also, the effect in the latter case being twice as great as that in the former. In fact, the Schæberle aberration is a defect that exists in all forms or combinations of lenses, and must, therefore, be taken into account if we wish to attain maximum efficiency in definition.

PHOTOGRAPHY BY THE AURORA BOREALIS.—Mr. J. E. Turner, writing in *The Amateur Photographer* for May 6, describes a unique photograph which he has obtained. It seems that on April 15 Gourock was visited by a very vivid display of the aurora borealis, which lasted from 10 to midnight. The moon having set at 9.13 p.m. and not rising again until 4.5 a.m. the next morning, he thought it might be possible to get a photograph merely by the light of the aurora borealis, and he consequently exposed a plate towards the northern horizon, giving an exposure of only two minutes with f/8 and a Paget xxxxx. plate. The negative, when developed with a very weak pyro and ammonia developer for about one hour, came out well and showed clearly the nearest land that was three miles distant, together with the houses, which were clearly defined, besides numerous trees in the foreground. The photograph is reproduced in the above-named journal. It is not mentioned whether an impress of the aurora itself was obtained, but only the statement: "the stars also nearest the zenith are faintly seen, the light from the aurora, of course, obscuring them."

MR. TEBBUTT'S OBSERVATORY.—The Report of Mr. Tebbutt's Observatory at Windsor, New South Wales, for the year 1897, shows that the number of observations made is up to the standard of former years. The 8-inch equatorial was employed for observing occultations of stars by the moon, 134 phases being noted, and numerous minor planets. Perrine's comet was also diligently watched for several weeks, and many variable stars and phenomena of Jupiter's satellites observed. The meteorological observations have been as usual regularly made. Seven years' meteorological observations are now in hand, and will be soon published; and when this is completed, there will be a period of thirty-five years of published data which will be invaluable for investigating the local climate. In consequence of recent local legislation, Mr. Tebbutt writes: "A notice was sent to the Minister of Public Instruction on October 11 last, that it was intended at the close of the year to discontinue the meteorological department, and the hope was expressed that the Government would see fit to continue the work at its own expense. A reply was received stating that the work would be continued . . . at the Hawkesbury Agricultural College, about four miles west of the Observatory." Such an arrangement as this was evidently very satisfactory, for it would have been a crime to have suddenly broken the continuity of what must be valuable data for investigating the climatic conditions of New South Wales. "After due inquiry," as Mr. Tebbutt further states, "at the close of the year, it turned out, however, that provision had not been made for continuing the Windsor meteorological work in all its departments. It is proposed to continue at this observatory observations of the daily rainfall by the two gauges, and to secure the monthly maximum and minimum air temperatures." We hope that the Government will not be long in seeing that due attention must be paid to the question of meteorology in New South Wales, and that, after private enterprise has carried on the work for so many years, it becomes a duty to see that a breach in the continuity of the observations is not made through lack of funds.

SOME NEW STUDIES IN KATHODE AND RÖNTGEN RADIATIONS.[1]

THE researches of Crookes, Lenard, and Röntgen have given to man a new eye; they have, perhaps, also given to nature a new light; they have certainly given to science more than one new problem. A vacuum tube may appear but a simple piece of apparatus; but were we acquainted in their entirety with the secrets that it contains, we should know much at present utterly unknown, not only as regards electrical action, but also in reference to the fundamental constitution of matter, and the

[1] Abstract of Friday evening discourse delivered at the Royal Institution on February 4, by Alan A. Campbell Swinton.

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true mechanism of energy. It is, in fact, for the reason that within the Crookes radiant matter tube it is possible to deal, not as in every day life with aggregates of matter, but perhaps individually with single molecules and single atoms floating apart in space, that so much attention is at present being devoted to this particular branch of physics.

Every one is now acquainted with what has become the quite ordinary phenomenon of the kathode rays. These excite luminescence in the glass upon which they fall, and cast a sharp shadow of any obstacle interposed in their path. When the tube is suitably placed in a magnetic field the shadow rotates and becomes at the same time smaller; the magnetic field having thus the property of concentrating the rays, and at the same time giving them a twist. This concentration of the kathode rays by means of a magnetic field, which has been studied by Birkeland and by Fleming, can be employed to show the intensely heating effect and erosive properties of the rays. Indeed by suspending a tube over one pole of a straight electro-magnet, and thus concentrating the rays to a point, it is possible by moving the tube or the magnet to actually engrave on the interior surface of the glass a figure of any desired form.

The more ordinary method of producing a concentrated kathode discharge is by employing as kathode a spherical aluminium cup, from the concave side of which the rays are given off normally to the surface. By employing two such cups, connected to the two secondary terminals of an induction coil supplied with alternating electric current, and giving at the secondary terminals a pressure of about 20,000 volts, the intense heating effect of the kathode rays can readily be shown by allowing them to fall upon a small fragment of quicklime. In this manner a brilliant and beautiful light is produced, and it is not at all improbable that it may eventually be found possible to obtain in this way, commercially and practically, high voltage electric lamps of much higher efficiency than the ordinary incandescent filament lamps, and possibly even rivalling arc lamps. In both these latter it is necessary that the incandescent substance should be a fairly good electrical conductor; whereas in the kathode ray lamp there is no such limitation, and consequently there is a much wider range of available refractory substances. It is also quite conceivable that in the future an electric furnace of this nature may be found of service in some of the more delicate of chemical investigations, where it is necessary to obtain in isolated substances exceedingly high temperatures. Indeed, already, Crookes and Moissan have employed this means for turning into graphite the surface of diamonds.

It is now becoming more and more generally believed that Sir William Crookes' original theory as to the nature of these kathode rays is correct. According to this theory they consist of material particles of residual gas, which, being similarly electrified by contact with the kathode, are violently repelled by the latter. This has been the view held for a long time by most English physicists, and the chief point of difference now appears to be whether these material particles are single atoms, single molecules, or larger aggregations of matter. This theory is supported by the erosive action of the rays, which are found after a short time to bore straight and very minute holes right through the block of quicklime in the kathode ray lamp. A model, consisting of a gilded pith ball suspended between two metal plates connected to a Wimshurst machine, may be used to roughly illustrate what is supposed to occur. The ball obtains an electrical charge from whichever plate it starts in contact with, and is violently repelled into contact with the other plate, and so on backwards and forwards. In a Crookes' tube, however, the velocity of the negative stream is undoubtedly much higher than that of the positive stream. This may be connected with the fact that the positive discharge is much more dispersive than the negative. Indeed, a tube while in action appears to be filled almost entirely with positively electrified atoms, while it is only behind the kathode and in the kathode stream itself that any negatively electrified atoms are to be found. It is, however, possible to show experimentally that something, at any rate, producing the same effect as a positive stream does exist at very high exhaustions. For this purpose a radiometer tube, as shown in Fig. 1, containing a small mill wheel with mica vanes, similar to those employed by Crookes, may be used. The wheel is mounted upon a sliding carrier, so that it can be moved bodily either out into the centre of the tube, when the kathode stream impinges directly upon the vanes, or back into an annex, when the vanes are quite outside the kathode line of fire. In the former position, as discovered by Crookes, the wheel rotates with great rapidity in a direction indicating an atomic stream from the kathode to the anode. In the latter position, with sufficiently high exhaustion, the wheel is found by the author always to rotate in an opposite direction, indicating a returning stream of atoms from the anode to the kathode, the anode stream passing outside of the kathode stream. As suggested by Prof. G. F. Fitzgerald, some action of this nature will perhaps explain the curious effects obtained by the author, and already noticed in NATURE for April 15, 1897, from which it appears that both the convergent and divergent cones of kathode rays in a focus tube are usually hollow, it seeming likely that if the supply of atoms to the active kathode surface is from all round the edge of the latter, the atoms may be all shot off again from the kathode in the form of a hollow cone, before they get further than a certain distance towards the centre.

Birkeland has shown that if a thin kathode stream, obtained by passing the rays from a flat kathode disc through a narrow slit in a piece of platinum serving as the anode, is deflected by a suitable magnetic field, it is split up into bundles of rays: and if allowed to fall upon the glass walls of the tube, it gives fluor-

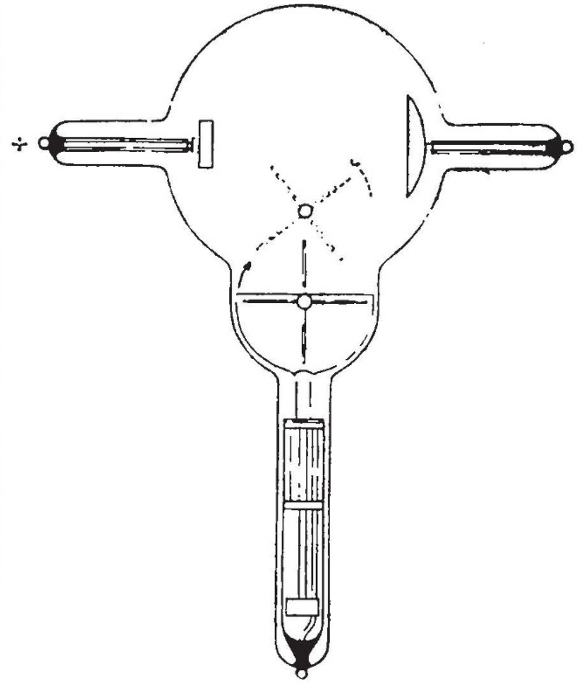

FIG. 1.

escent bands of alternate brightness and darkness. The author has been able to photograph these bands by simply binding a strip of sensitive photographic film round that part of the bulb upon which the bands are formed, and making a single discharge by a single break of the contact breaker of the induction coil. Further, by inserting between the glass and the photographic film a piece of very thin black paper, so placed as to cover only one half of the image, it is possible to obtain a photograph of the bands, one half of which is due to the visible fluorescent luminosity of the glass, and the other half to the invisible Röntgen rays. Photographs produced in this manner show that the Röntgen rays are also under these conditions given off in bands, which are co-terminous with the fluorescent bands, though photographically fainter than the latter. It is important to note that in the Röntgen ray photograph the greatest effect is always produced by the least deflected of the kathode-ray streams; that is to say, by that stream which is presumably travelling at the greatest velocity. Here we have a probable explanation of the existence of the bands, which are most likely due to the atoms of the kathode rays having from the first different velocities imparted to them, due to the oscillatory character of the induction coil discharge, and from their gathering into groups travelling at

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different velocities, on the well-known principle that occasions the traffic in the street to form knots of maxima and minima, owing to the faster vehicles catching up the slower, and being impeded by them.

Passing on to the production of X-rays in tubes of the ordinary focus type, it is found that the particular material employed for the anti-kathode surface considerably affects the production of the Röntgen rays. This is a subject that was first investigated by Prof. Sylvanus Thompson, who found that the best absorbents were the best emitters of the Röntgen rays; in other words, that the best materials for the anti-kathode were metals of the highest atomic weight. If, as seems probable, the Röntgen rays are produced by the sudden removal of velocity from the kathode ray atoms by collision with the anti-kathode, this is in accordance with what would be expected, as substances of high atomic weight would obviously be the most efficient by reason of the greater inertia of their atoms. The author has made numerous experiments with various metals for the anti-kathode, comparing them in a tube in which the anti-kathode, made half of one metal and half of another, was movable. By jerking the tube, either half could be brought opposite the kathode, and put into use; so that under exactly similar conditions it was possible to accurately compare the efficiency of the two substances. Of available substances, platinum was found to be much the best.

The usual method adopted for varying the resistance of a Röntgen ray tube, and thus modifying the character of the

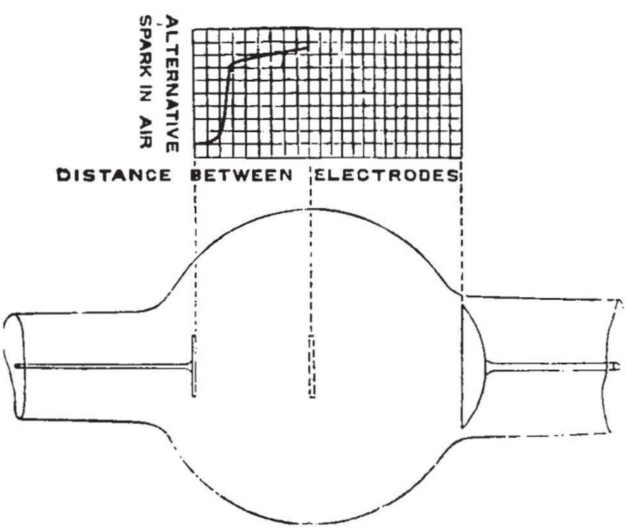

FIG. 2

Röntgen rays it produces, so as to obtain the exact penetrative quality that is desired, is by varying the vacuum. The higher the exhaustion the greater is the resistance in the passage of the discharge, the greater appears to be the velocity of the kathode stream, and the more penetrative are the Röntgen rays. This variation of the vacuum is usually effected by heating the tube, which has the effect of driving out into the interior molecules of the residual gas condensed or occluded upon the glass. Apart from this, however, it is suggested that very possibly the temperature of the contents of the tube and the consequent kinetic energy of the molecules, which is greater the higher the temperature, may in itself assist the passage of the discharge. The author has found other means of varying the resistance of the tube, and altering the character of the Röntgen rays that it generates, which do not depend upon either the degree of exhaustion or upon the temperature. According to one method the tube is fitted with two or more kathodes of different sizes, but all focussing upon the same anti-kathode. With such a tube it is found that the smaller the kathode the greater is the E.M.F. required to cause the electric discharge to pass through the tube, and the more penetrative are the Röntgen rays generated. Another method of effecting regulation consists in making the anti-kathode, which is also the anode, movable, and altering the distance between it and the kathode. Still another, in making the kathode movable, and altering its position relative to the glass walls of the tube. Some of the author's experiments in these directions have already been described in NATURE for April 29 and May 27, 1897. He has, however, now further studied the cause of these effects by means of a tube in which the positions of both anode and kathode can be altered independently by means of a magnetic adjustment. Fig. 2 shows a portion of this tube, and above it is drawn a curve representing, in terms of the alternative spark in air, the difference of potential required to cause a discharge to pass through the tube with varying positions of the anode. In the diagram the abscissæ represent the distance between anode (which also formed the anti-kathode) and the kathode, divided in tenths of an inch, while the ordinates represent also in tenths of an inch the length of the alternative sparks in air between two brass balls inch in diameter. Starting with the anode in its furthest position from the kathode, and moving it gradually towards the latter, it will be observed that at first there is a slight gradual increase in the length of the alternative spark. Then for the next small movement there is a very sudden increase, and after that a further gradual increase till the point marked in dotted lines is reached, which denotes the limit of travel that the anode was allowed. Similarly, Fig. 3 represents the effect of moving the kathode in the same tube, the anode being stationary in the position shown. Here, as will be seen, the less the distance between the kathode and anode the less is the length of the alternative spark. This distance in this case

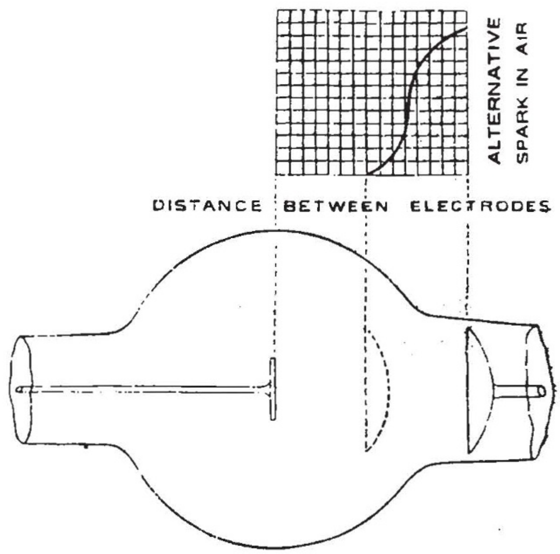

FIG. 3.

does not appear to be the determining factor, as it is more than counterbalanced by the more important factor of the position of the kathode relatively to the glass walls of the tube. Starting with the kathode as far away as possible from the anode, and moving it towards the latter, there is a gradual decrease in the length of the alternative spark to commence with, then a further, much more rapid decrease, as the kathode emerges from the annex, and a still further, but less sudden decrease, as the kathode is moved away from the glass walls out into the bulb. Now as to the effect upon the Röntgen rays, as it has been before remarked, the greater the resistance of the tube and the greater the E.M.F. necessary to cause a discharge to pass, the greater is the velocity of the atoms that form the kathode stream, and the more penetrative are the Röntgen rays produced. Further, so far as the movable kathode is concerned, the supply of atoms appears to be of great importance. If penetrative Rontgen rays are desired, the access of atoms to the kathode must be restricted. If only a few atoms can get to the kathode, these are projected at great velocity; if there is too ready access, the atoms crowd in upon the kathode, and the electrical charge of the latter is unable to throw them off with much speed. It is possible to restrict the supply of atoms to the kathode either by bringing the latter back into a recess or annex, as in the tube just shown, or by using a tube in which both kathode and anti-

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kathode are fixed, but in which there is a movable conical glass shield which can be brought up from behind the kathode so as to impede the access of the atoms which, as we have seen, come in round the edges of the kathode, to any desired extent. This tube regulates just as did the adjustable kathode tube.

In order to produce sharply-defined Röntgen photographs, it is of course of the utmost importance that the rays should be given off from a very small area. The sharpness of definition varies considerably with different tubes, and a ready means of judging as to their quality in this respect is very useful.

The best and most accurate method is by means of pin-hole photography. Seeing that the Röntgen rays are not refracted, photography with a lens is, of course, out of the question; but with a pin-hole, very accurate and distinct images can be obtained. It is only necessary to place a sheet of lead, pierced by a pin-hole, near the tube, and then to examine the rays coming through the hole with a fluorescent screen, placed some way behind the lead sheet, in order to see exactly the size and shape of the active area of the anti-kathode; or, instead of the screen, a photographic plate may be employed and the effect recorded. Fig. 4 shows three pin-hole photographs of the anti-kathode taken in this way, giving the effect produced with three different distances between the kathode and anti-kathode. The largest figure is produced with the greatest distance, and *vice versâ*. It will be observed that, owing to the anti-kathode being placed obliquely to the kathode, the figures are all oblique, though somewhat imperfect, conic sections; further, that when the distance between kathode and anti-kathode is great, we have a section of the divergent cone giving a hollow ring with a central spot. The ring gets smaller and smaller, and finally disappears as the distance between the electrodes is reduced, and the focus approaches the anti-kathode. It will also be noticed that where in the ring portion of the figures the kathode rays strike most normally—that is to say, at one of the two points of greatest curvature of each ellipse—the Röntgen rays are produced more actively than in the remaining portion where the kathode rays impinge on the anti-kathode more on the slant.

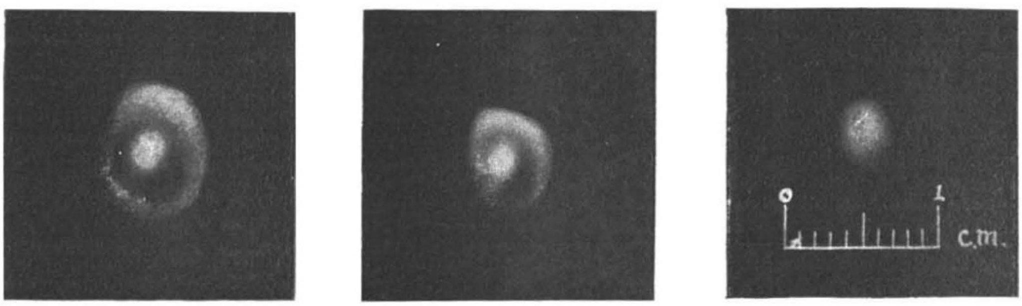

FIG. 4.

By some it is imagined that because the Röntgen rays are so very penetrating, therefore they are of the nature of an invisible light of great intensity, which, though not affecting the human retina, acts upon photographic plates very powerfully. This is quite erroneous, and, as a matter of fact, the photographic effect of Röntgen rays is relatively very feeble. The author has investigated this by exposing two photographic plates, respectively, to a very powerfully excited Röntgen-ray tube, screened by black paper to remove the visible luminosity, and to the light of a single standard candle By adjusting the distances and exposures so as to obtain a precisely equal effect in both cases, he has found that the photographic power of the particular Röntgen-ray tube investigated was about one-sixtieth of one standard candle.

With regard to the true nature of the Röntgen rays, there have been many theories. There is the original suggestion of Röntgen himself, that they may possibly consist of longitudinal waves in the ether. Others have thought that they were possibly ether streams or vortices. There is a theory that they consist of moving material particles similar to the kathode rays. There is the more generally received doctrine, that they are simply exceedingly short transverse ether waves, similar in all respects to the waves of light, only so much shorter than the most ultra-violet waves hitherto known that they pass between the molecules of matter, and are consequently neither refracted nor easily absorbed or reflected by any media. Lastly, there is the theory, first suggested to the writer early in 1896 by Prof. George Forbes, and recently independently enunciated and elaborated by Sir George Stokes, which imagines them to be frequently but irregularly repeated, isolated, and independent disturbances or pulses of the ether, each pulse being similar, perhaps, to a single wave of light, and consisting of a single transverse wave or ripple, but the pulses following one another in no regular order, or at any regular frequency, as do the trains of vibration of ordinary light.

Then, again, there is the question of the mechanism by means of which the Röntgen rays are produced. They are generated by the impact of the kathode stream upon the anti kathode, and it is now becoming more and more certain that the kathode stream consists of negatively charged atoms travelling at enormous velocity. If we accept this view, there are obviously several methods by which we may imagine the Röntgen rays being generated by the impact of the travelling atoms upon the anti-kathode. Each kathode-ray atom carries a negative charge, while the anti-kathode is positively charged, so that when the two come into contact an electrical discharge will take place between them. An electrical oscillation will thus take place in the atom just as in the brass balls of a Hertz oscillator, and transverse electromagnetic waves will be propagated through the ether in all available directions. As the electrostatic capacity of the atom must be exceedingly small, the periodicity of oscillation and the wave frequently will be enormous, while at the same time the oscillation will probably die out with sufficient rapidity to admit of only one or two complete periods. At the same time the greater the difference of potential between atom and anti-kathode at the moment of impact the greater will be the amplitude of oscillation, and the more vigorous and far-reaching the etheric disturbances.

Or we may imagine a more purely mechanical origin for the Rontgen rays. It is believed that the velocity of the kathode rays is enormous, being, as recently measured by J. J. Thomson, over 10,000 kilometres per second; and though Lodge, in his well known endeavours to detect a movement of the ether by dragging a material body through it obtained only negative results, of course he could not possibly obtain any velocity at all comparable to this. Assuming that at the velocity of the kathode-ray atoms these do appreciably drag the ether with them, there may be some other effect produced, analogous to the atmospheric effect that is noted as the crack of a whip or a clap of the hands, as each atom hits the anti-kathode and rebounds.

Since this paper was written, the author's attention has been called to Prof. J. J. Thomson's suggestion in the *Philosophical Magazine* for February, that the Rontgen rays consist of very thin and intense electromagnetic pulses produced in the ether by the sudden stoppage by the anti-kathode of the electrified particles of the kathode stream.

Or, again, it is conceivable that the phenomenon is merely one of heating, and that the kathode stream atoms are, by impact with the anti-cathode, raised to such an enormous temperature, that they give off for a short space of time super-ultra-violet light. Taking a velocity for the atoms of 10^9 centimetres per second, as found by J. J. Thomson to be the minimum velocity of the kathode stream, and calculating the temperature to which a nitrogen atom would

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be raised if, when travelling at this speed, it were instantly brought to rest and the whole of its energy converted into heat in the atom itself, we have the result that the rise in temperature is no less than the stupendous figure of approximately 50,000,000,000 degrees Centigrade. This is upon the assumption that the specific heat remains constant; but allowing for this, and even allowing for the merest fraction of the energy being converted into heat in the atom itself, there is obviously an ample margin to admit of a temperature being actually obtained enormously transcending anything of which man has any knowledge. Perhaps it may be objected that it is only when we come to deal with aggregations of atoms that we can speak of heat, and that a hot atom is a physical absurdity. If, however, we look upon heat as a rhythmic dance of the atoms, perhaps we may also contemplate the possibility of a single atom executing a *pas seul*, and giving pulses to the ether at each of its movements. In any case, this difficulty disappears if we imagine the travelling particles each to consist of an aggregation of atoms. The fact that substances of high atomic weight form the most efficient anti-kathodes, lends force to the suggestion that the Röntgen rays are produced in some way by the sudden removal of velocity from the atoms that form the kathode stream, owing to the collision of these latter with the comparatively stationary atoms of which the anti-kathode is composed; while the effect observed with the pin-hole photographs of the anti-kathode, in which, as has been seen, the kathode rays that strike the anti-kathode most normally are the most effective in producing Röntgen rays, is also in accordance with this view. At the same time, the fact that in Röntgen ray photographs of Birkeland's kathode ray spectrum it is always the least deflected ray that produced the greatest photographic action, goes to show that the higher the velocity of the kathode ray atoms the more effective these latter are in generating the Röntgen rays.

More than two years have now elapsed since the date of Röntgen's discovery, and nearly twenty years since the commencement of the researches of Crookes. Here, as always, we find that "Art is long, opportunity fleeting, experiment uncertain, judgment difficult." Thus wrote the Greek Hippocrates some twenty-three centuries ago, and time has not impaired the truth of the ancient aphorism.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The Junior Scientific Club met at the Museum on Wednesday, May 18. After private business, Rev. G. D. Allen exhibited his collection of European Cicindelidæ and Carabidæ. Mr. N. V. Sidgwick (Ch. Ch.) read a paper on "Tautomerism," which gave rise to a short discussion, and Dr. Gustav Mann gave an account of Miss L. Huie's further researches on changes produced in Drosera by feeding. The foods recently investigated include peptone, milk, globulin, and urea. The results previously obtained with egg albumin are confirmed by the three former foods, with important modifications. Urea acts as a poison.

CAMBRIDGE.—On June 15, honorary degrees are to be conferred on General Ferrero (Italian Ambassador), the Master of the Rolls, Mr. Leonard Courtney, Mr. James Bryce, Prof. Dicey, Sir Edward Poynter, Sir William Turner, F.R.S., the Master of Balliol, Mr. F. C. Penrose, F.R.S., Prof. S. R. Gardiner, Sir Henry Irving, and Mr. Charles Booth, author of the valuable inquiry into East-end life and poverty.

The honorary degree of M.A. is to be conferred also on Dr. Arthur Willey, Balfour student, for his excellent researches on *Nautilus*.

The General Board of Studies recommend the establishment of a University Lectureship in Chemical Physiology, but in view of the present state of the University finances the post will be without stipend from the Chest.

Dr. Joseph Griffiths has been appointed to the new Readership in Surgery, which takes the place of the suspended Professorship.

THE Report of the Council of the City and Guilds of London Institute upon the work of the Institute during last year has just been published. Before referring in detail to the several branches of the Institute's work, the Council point out that the percentage of expenditure on the teaching staff is 61·9 per cent. at the Central Technical College, and 58·2 per cent. at the Finsbury Technical College, while the average of fourteen University Colleges is 64·9 per cent. The comparison relieves the Council of any suspicion of excessive expenditure. The Research Fellowship at the Central Technical College, founded by the Leathersellers' Company during the mastership of Dr. W. H. Perkin, F.R.S., was awarded at the commencement of the summer term, with the sanction of the Company, to Mr. W. S. Gilles and Mr. F. F. Renwick, who were together engaged in investigating the oxidation products of the so-called artificial camphor. Dr. Williamson, the holder of the Salters' Company's Fellowship, has continued his investigations at the College on the actual composition of the wheat grain grown on Sir John B. Lawes's experimental farm at Rothamsted, and that of the Royal Agricultural Society at Woburn. A number of other investigations have been carried out in the engineering, physics, and chemical laboratories, and the results in many cases have been published in the technical and scientific journals. Prof. Ayrton rightly points out that the assignment of space for an electro-chemical laboratory merits attention in consequence of the rapidly growing importance of the electro-chemical industry. It is certainly time that a well-equipped laboratory was established to provide facilities for investigations in electro-chemistry.

SCIENTIFIC SERIALS.

American Journal of Science, April.—On the temperature coefficients of certain seasoned hard steel magnets, by Arthur Durward. The author examined the temperature coefficients of a large number of stout magnets seasoned according to the method of Barus and Strouhal. If the temperatures are plotted as abscissæ, and the percentage losses of magnetic moment as ordinates, the curves obtained show a slight concavity upwards in most cases, which implies that the loss of moment becomes accelerated at the higher temperatures. Some specimens show an anomalous behaviour, which can be traced to local softening of the steel, and a temperature coefficient considerably augmented in consequence.—The skull of Amphictis, by E. S. Riggs. Describes an almost complete skull in the Princeton collection from the phosphorites. It is unusually small, the length from the incisors to the condyles being ·074 m. The cranium is well expanded, showing a large and well-convoluted brain. The nasals are narrow and slender as in the civets. The genus forms a connecting link between the Mustelidæ and the Viverridæ, and supports Schlosser's theory as to their common origin.—New form of make and break, by C. T. Knipp. The ordinary form of make and break for a seconds pendulum consists of a platinum tip brushing through a mercury drop. This is subject to oxidation and other troubles. The author uses a simple spring device which is always in order, and gives a sharply defined tick for transmission. A T-shaped lever of thin sheet brass is attached to the pendulum. As it swings, each end alternately comes into contact with a fine steel spring. In the middle position, the springs are both in contact, and the circuit is established and transmits the signal.—Rhodolite, a new variety of garnet, by W. E. Hidden. During the past fifteen years there has been found from time to time, over a very limited area in western North Carolina, a variety of garnet called rose garnet. It is distinguished by the variety of its tints, by its transparency, and by its freedom from inclusions and other imperfections. Its specific gravity is 3·838. The ratio of MgO to FeO is almost exactly 2 : 1. The detailed formula is $2Mg_3Al_2(SiO_4)_3 \cdot Fe_3Al_2(SiO_4)_3$.

Bulletin of the American Mathematical Society, April.—The February meeting, in accordance with the rule lately set up by the Society, was an all-day one. This arrangement gives opportunity for not only scientific, but also social intercourse. There was a good attendance of members, and many papers were read.—The theorems of oscillation of Sturm and Klein (first paper), by Prof. Böcher. The author states that Sturm's work (*Liouville's Journal*, 1836) has been regarded by some writers as not sufficiently rigorous, and that other methods must be substituted for his; for instance, the method of successive approximations recently employed by Picard for establishing some of the theorems. Prof. Böcher considers that Sturm's work can be made perfectly rigorous without serious trouble and with no real modification of method. This is what

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