experiments, and finds it much smaller than Herapath did, namely, 1·557.

Prof. Mayer also gave formulæ of transmission of Röntgen rays through glass, tourmaline and herapathite. To determine whether rays just go through or nearly go through, he uses a wire grating which will appear in the picture if rays go through. Transmission depends on the thickness of the glass plus the time of exposure. Glass of various thickness is used, one plate being superposed upon another in successive gradations. The eye cannot distinguish a difference less than about 1/100, and this is what passes through glass of five millimetres thickness. If we begin with glass 1/10 millimetre thick, it absorbs 1/10 of the rays, and each superposed 1/10 millimetre absorbs 1/10 of the residue, so that the formula in general is $I' = Ia^t$. It is evident, therefore, that there is no constant ratio of comparison of absorption by different materials, because the successive powers of "a" have not the same ratio to each other that the first powers have. In the case of herapathite the absorption (a) is found to be ·9382, so the formula becomes $I' = I \cdot 9382^t$. The formula for tourmaline is the same as for glass, so tourmaline is a very imperfect substance to use.

Prof. Ogden N. Rood read a paper detailing his experiments in reflecting the X-rays, which have enabled him to reflect 1/260th part of the rays incident on platinum at an angle of 45° (see NATURE, April 30, p. 614).

Prof. Arthur W. Wright read a paper on the relative permeability of magnesium and aluminium by Röntgen rays. He reported experiments showing that magnesium is much more permeable than aluminium. Magnesium is also more readily wrought than aluminium, thus making it much more desirable to use in the investigation of these rays.

Prof. T. J. J. See, of Chicago University, read a paper on double stars, giving results of three years' observations. He concludes that at the end of 115 years we know accurately only forty; that there is only evidence of disturbing bodies in a few cases, which are indecisive; that great eccentricity of orbit prevails, the average being twelve times as much as that of planetary orbits, and that the law of gravity is rendered probable and may be hereafter confirmed by spectroscopic investigation.

Among other papers read are:—The geological efficacy of alkali carbonate solutions, by E. W. Hilgard, read by G. Brown Goode; on the colour relations of atoms, ions, and molecules, by M. Carey Lea, read by Ira Remsen; on the characters of the Otocœlidæ, by E. D. Cope; on the determination of the coefficient of expansion of Jessop's steel, between the limits of 0° C. and 64° C., by the interferential method, by E. W. Morley and Wm. A. Rogers; on a remarkable new family of deep-sea Cephalopods (*Opistotenthis*), and its bearing on molluscan morphology, and on the question of the molluscan archetype, by A. E. Verrill; on *Pithecanthropus erectus* from the Tertiary of Java, which was discovered by Dubois in 1895, by Prof. Marsh; on the separate measurement, by the interferential method, of the heating effect of pure radiations and of an envelope of heated air, by Wm. A. Rogers; judgment in sensation and perception, by J. W. Powell; exhibition of a linkage whose motion shows the laws of refraction of light, by A. M. Mayer; location in Paris of the dwelling of Malus, in which he made the discovery of the polarisation of light by reflection, by A. M. Mayer. Ira Remsen read a paper on some studies in chemical equilibrium, and several papers were read by title.

The Academy adjourned to meet at New York, November 17, 1896.

WM. H. HALE.

THE MANUFACTURE OF ARTIFICIAL SILK.

LANCASHIRE is on the eve of some important expansions of the textile trades, for, from an interesting article in the *Times*, it appears that the manufacture of artificial silk from wood pulp will shortly be added to her industries. At present the wood-silk comes from France, large works having been established at Besançon under patents granted to Count Hilaire de Chardonnet, who discovered the process, and first established in 1893 the fact that it might be made into a commercial success. The demand for the new commodity increased so considerably that the idea of introducing its manufacture into England was mooted, with the result that a number of silk and cotton manufacturers met to discuss the question, and finally sent out to Besancon a deputation, consisting of some of their own number, an engineer, a chemist, and a lawyer, to investigate the subject thoroughly. This was done, and the outlook was found to be so promising that certain concessions have been secured and a company is now in process of formation, and, to begin with, a factory, which will cost £30,000, is to be built near to Manchester for the manufacture of artificial silk yarn from wood pulp, for sale to weavers, who will work it up by means of their existing machinery. The way in which wood pulp can be converted into silk yarn is explained in the *Times*. The pulp, thoroughly cleansed, and looking very much like thick gum, is put in cylinders, from which it is forced by pneumatic pressure into pipes passing into the spinning department. Here the machinery looks like that employed in Lancashire spinning sheds, except that one of the pipes referred to runs along each set of machines. These pipes are supplied with small taps, fixed close together, and each tap has a glass tube, about the size of a gas-burner, at the extreme point of which is a minute aperture through which the filaments pass. These glass tubes are known as "glass silkworms," and some 12,000 of them are in use in the factory at Besancon. The effect of the pneumatic pressure in the cylinders referred to above is to force the liquid matter not only along the iron tubes, but also, when the small taps are turned on, through each of the glass silkworms. It appears there is a scarcely perceptible globule. This a girl touches with her thumb, to which it adheres, and she draws out an almost invisible filament, which she passes through the guides and on to the bobbin. Then, one by one, she takes eight, ten, or twelve other such filaments, according to the thickness of the thread to be made, and passes them through the same guides and on to the same bobbin. This done, she presses them together with her thumb and forefinger, at a certain point between the glass silkworms and the guides. Not only do they adhere, but thenceforward the filaments will continue to meet and adhere at that point, however long the machinery may be kept running. In this way the whole frame will soon be set at work, the threads not breaking until the bobbin is full, when they break automatically, while they are all of a uniform thickness. The new product is said to take dye much more readily than the natural silk. The chief difference in appearance between the natural and the artificial silk is in the greater lustre of the latter. The success already secured by the new process in France is such that the introduction of the industry into Lancashire is expected to produce something like revolution in the conditions of trade there, not only by bringing into existence a new occupation, but also by finding more work for a good deal of the weaving machinery that is now only partially employed.

A THEORY OF THE X-RAYS.[1]

THE principal facts, which any satisfactory theory of the X-rays is called upon to explain, may be summarised as follows:

(1) The production of the rays by electric impulse, at the kathode,[2] in a highly exhausted enclosure.

(2) Propagation in straight lines and absence of interference, reflection, refraction and polarisation.

(3) The importance of density of the medium as the determining factor in the transmission of the rays.

(4) The production of fluorescence and actinic effects, and the action on electrified conductors.

Two theories have been proposed to account for these remarkable phenomena: (1) the theory of longitudinal waves; (2) the theory of projected particles.

In reference to the first theory it may be said that unless it is proved that an oscillatory discharge is essential to the production of the X-rays, there can be no reason for supposing that these rays are of a periodic nature—that they are wave-motion as commonly understood. The absence of interference, reflection and refraction is also a very formidable difficulty. Attempts have been made to account for the absence of these invariable accompaniments of every known form of wave-motion, but, as I think, with very indifferent success.

The most serious difficulty in the second theory is the attempt to explain the passage of the electrified particles of the residual gas (or of the electrode) through the walls of the

[1] From the *American Journal of Science*, April.

[2] Even should further experiment prove that the X-rays proper originate at the first obstruction encountered by the discharge, the fact remains that this discharge originates at the kathode.

vacuum tube. The query at once arises, if glass is permeable to these particles in virtue of their relatively great velocity, why is it not permeable (in lesser degree) to the same particles moving with smaller velocities? That it is not, is evident from the fact that vacuum tubes retain their high degree of exhaustion unimpaired for years.

In view of these difficulties, I would propose a third theory, which may be called the "ether-vortex" theory.

Let it be supposed that the X-rays are vortices of an intermolecular medium (provisionally, the ether[1]). These vortices are produced at the surface of the kathode, by the negative charge, which forces them out from among the molecules of the kathode.

Let us now apply the tests above mentioned.

According to this theory, an oscillatory discharge, while it may be just as effective as a series of separate impulses, is not essential to the formation of the vortices. The vortices being forced outwards from the surface of the kathode by the negative charge, the effect of the positive charge at the anode would be to drive them in. Hence their appearance at the kathode alone.

One of the greatest puzzles connected with the behaviour of the X-rays is the fact that while they can pass almost unimpeded through air at atmospheric pressure (let alone water, glass, wood, flesh, bone, and metals) *when once outside the enclosure in which they are produced*, they cannot even reach the walls of the enclosure, except there be a very high vacuum within. This problem receives a very natural solution if it be considered that, in order that ether-vortices may result from the electrical impulse, this impulse must be communicated to them; and must not be dissipated in the interchange of molecular charges which accompanies, or rather produces, the discharge at moderate or high pressures.

As exhaustion proceeds there are fewer molecules present to effect this discharge with sufficient rapidity, and as this limit is approached there will be a division of the energy of the electric impulse between the electrified molecules and the ether-vortices, and in the end all the energy of the discharge will be confined to the latter.

The reason for the non-appearance of the rays under ordinary conditions is not that the rays cannot reach the walls of the enclosure or pass through them, but that they cannot form at all. The propagation of vortices in straight lines, the absence of interference phenomena, of reflection, refraction and polarisation, follow from the properties of vortices, and from the absence of anything corresponding to a wave-front. The passage of an ether-vortex through a mass of matter may be compared with a passage of a smoke-ring through a wire gauze screen or a series of such; and as the motion of the rings is more impeded the greater the diameter and the number of wires per unit volume, so, the greater the number and the size of the molecules—that is, the greater the density—the more effective will the medium be in dissipating the energy of the ether-vortices.

The production of fluorescence, actinic effects, and the dissipation of electric charges by light (which is an ether motion) would make it at least probable that similar (though perhaps not identical) effects would be produced by the motions of ether vortices.

Prof. J. J. Thomson has measured the velocity of kathode rays and obtained a result so very far less than the velocity of light as to preclude entirely the idea of there being any connection between the two. If these results can be made to apply to the X-rays, the analogy with the properties of smoke-rings would lead us to expect such a result. The kathode rays have been shown by Lenard to have a considerable range in their properties, depending on the mode of their origin.[2] It seems likely that their velocities are to a considerable extent dependent on the potential and the suddenness of the electrical impulse; and if this were shown to be true of the X-rays, it would be to that extent a confirmation of the theory.

The foregoing evidence may be considered scarcely sufficient to entitle the proposition here advocated to the dignity of a theory, but it may at least merit consideration as a working hypothesis which may serve as a guide in future experiment.

ALBERT A. MICHELSON.

[1] A possible objection occurs to the formation of ether-vortices in a medium which is usually considered free from viscosity; but the fact that vibrating molecules can and do communicate their motions to the surrounding ether shows that the communication of vortex motion may also be possible.

Though not a necessary part of the theory, it may be considered that the expulsion of the ether-vortices is due to an accumulation of ether in the kathode, and this would lend support to the theory that this accumulation is not merely a result of the negative charge, but that this excess of ether is what constitutes the negative charge.

[2] The distinction between the X-rays and the kathode rays appears to be somewhat artificial, and it seems probable that the X-rays are only kathode rays sifted by the various media they have traversed.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The Oxford University Junior Scientific Club will hold a conversazione on Tuesday evening, May 26. The rooms and laboratories of the University Museum, Oxford, will be thrown open by permission of the delegates and professors, and apparatus and experiments illustrating recent progress in the various branches of natural science will be exhibited. During the evening Prof. Silvanus P. Thomson will give a lecture on "Luminescence," with demonstrations.

On Tuesday, June 2, before the above Club, Prof. W. Ramsay, F.R.S., will deliver the fifth annual Robert Boyle Lecture, on "Argon and Helium, the two recently discovered gases." The "Robert Boyle Lecture" was instituted in 1892, and the lecturers hitherto have been Sir Henry Acland (1892), Lord Kelvin (1893), Prof. A. Macalister (1894), Prof. A. Crum Brown (1895).

The vacancies in the Public Examinerships in the Honour School of Natural Science have been recently filled up as follows:—In Animal Morphology, Prof. E. Ray Lankester and Mr. Adam Sedgwick; in Botany, Prof. D. H. Scott and Mr. R. W. Phillips; in Geology, Prof. A. H. Green and Mr. J. E. Marr; in Physics, Mr. R. E. Baynes; in Chemistry, Prof. W. Ramsay; and in Animal Physiology, Prof. C. S. Sherrington.

The Scholarships and Exhibitions advertised for proficiency in Natural Science are not numerous this year. Merton and New College offer each one, the examination to be held conjointly by the two colleges at the end of June. Magdalen offers one or more Demyships in Natural Science for competition in October, and the Delegacy of Non-Collegiate Students offers a scholarship for Chemistry. There seems to be a tendency at the present time to curtail the number of scholarships in Natural Science.

The Hope Professor of Zoology is giving a course of public lectures at the Museum, on the Hope Collections. The second lecture of the series will be given on Wednesday, May 27, at 2.30 p.m.

Prof. H. A. Miers, F.R.S., Waynflete Professor of Mineralogy, gave his inaugural lecture at the University Museum on Wednesday last.

A Decree will be proposed on the 26th inst. providing for the enlargement and alteration of certain rooms in the University Museum, in order that they may be adapted to the purposes of the Professor of Mineralogy.

Mr. G. F. Scott Elliot gave a lecture to the Ashmolean Society last Monday, on the race elements of South Africa.

CAMBRIDGE.—The dates of the examinations for entrance scholarships and exhibitions in Natural Science at the several colleges during the next academical year, have been announced as follows:—St. John's and Trinity, November 3, 1896; Pembroke, Caius, King's, Jesus, Christ's, and Emmanuel, November 17, 1896; Peterhouse and Sidney, Clare and Trinity Hall, December 8, 1896; Downing, April 20, 1897. The subjects are in General Chemistry, Physics, Zoology, Botany, Geology, and Physiology, two or more sciences being required. Application for particulars should be made to the respective tutors some weeks before the date of the examination. The yearly value of the scholarships varies from £80 to £40.

Vacancies for students of Biology at the University tables in the Zoological Stations of Naples and Plymouth are announced. Applications to occupy these are to be sent to Prof. Newton by May 27.

THE University of Utrecht will celebrate the 260th anniversary of its foundation on June 22 and five following days.

MR. JOHN H. ROCKEFELLER has given to Vassar College (women's) 100,000 dols. for a new building, to be either dormitory or recitation hall.

MR. ANDREW CARNEGIE has given to the city of Duquesne, Iowa, a library, gymnasium, and public bath. The buildings are to cost 150,000 dols.