d the distance between the centres of two doublets, the number of doublets in unit length of a chain $= 1/d$; hence $N/d = I$, or $i = Idpe$.

Now we have seen that

$$I = Nm\left(\frac{\epsilon^x + \epsilon^{-x}}{\epsilon^x + \epsilon^{-x}} - \frac{1}{x}\right) = Nm\frac{x}{3}$$ along the straight part of the curve when n is smaller.

Also

$$x = \frac{m(X_0 + kI)}{R\theta}$$

We determine for I, and therefore i, in terms of X_0, by the graphical method; but it will bring out the main points of the theory if I confine myself to intersections along the straight part of the curve, where

$$I = Nm\frac{x}{3} = \frac{Nm^2}{3}\frac{(X_0 + kI)}{RT}$$

So

$$I = \frac{\frac{Nm^2}{3}X_0 \times \frac{1}{RT}}{1 - \frac{Nm^2k}{3RT}}$$

Or if we take a temperature T_0, such that $\frac{Nm^2}{3RT_0}k = 1$.

$$I = \frac{1}{k}\frac{X_0T_0}{T - T_0}$$

$$i = \frac{1}{k}\frac{X_0T_0dpe}{T - T_0}$$

Thus σ, the specific conductivity of the metal, $= \frac{1}{k}\frac{dpeT_0}{T - T_0}$.

Thus the conductivity becomes infinite, or the resistance vanishes when $T = T_0$. When we take the accurate solution instead of the approximate one, we find that the conductivity, though very great, is not infinite; the curve 1 bends round and meets the straight line, and when the intersection takes place in the curved portion the current no longer follows Ohm's law. We thus see that in the neighbourhood of a certain temperature the resistance diminishes with great rapidity, a point brought into great prominence by Kamerlingh Onnes.

If we compare the external force with the force kI, due to the atoms, we see from these equations that $kI/X_0 = T_0(T - T_0)$; so that near the critical temperature the force due to these atoms is enormously greater than the external force, so that the chains are held mainly by the forces between the atoms, and we can easily see by the graphical method of solution that when the temperature is below the critical temperature we can withdraw the electric force and still leave the greater part of the chains intact.

Super-Conductivity.

Let us now consider what happens when the temperature is diminished; the slope of the line (1) continually decreases and the intersection of this line with the curve gets further and further away from the origin; when the intersection comes on a part of the curve at an appreciable distance from the tangent at the origin, Ohm's law will no longer hold. Suppose that the slope of the line (1) has fallen so that, as in Fig. 2, it is less than that of the tangent at the origin to the curve $I = NMF(x)$, and after the application of a force X_0 suppose the force is gradually removed, the value of I corresponding to the diminished force will be got by drawing parallels to PQ continually getting nearer to the origin, and its value when the force has been entirely removed by drawing a parallel through the origin itself. We see from the figure that in this case the line through the origin will intersect the curve again at S, showing that I retains the finite value SN after the electric force has disappeared. From the point of view of this paper, however, the part played by the electric force in metallic conduction is to polarise the metal, *i.e.*, to form chains: when once these are formed the electricity is transmitted along them by the forces exerted by the atoms on the electrons in their neighbours. Thus if the polarisation remains after the electric force is removed the current will remain too, just as it did in Kamerlingh Onnes' experiment with the lead ring. The argument is similar to that by which Weiss explained the existence of permanent magnetism below a critical temperature.

The remarkable results obtained by Kamerlingh Onnes only occur at the temperature of liquid helium; at the temperature of liquid hydrogen the metals show no sign of super-conductivity, the discovery of which is thus a result of being able to lower the lowest available temperature a few degrees; it is a very striking instance of the truth of Browning's line:

The little more and how much it is.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The General Board of Studies, in its annual report to the Senate, reviews the work done and progress made in the experimental departments of the University during the academic year, 1914–15. A large proportion of the scientific staff and some forty of the laboratory assistants are absent on military service; this, together with the enlistment of most of the students of military age, has led to a diminution of the usual output of original experimental investigation. A large amount of experimental work has been done gratuitously for a number of Government departments in connection with problems arising out of the war, and certain of the laboratories have been able to offer such facilities to professors of Belgian universities as have enabled them to continue the instruction of their pupils in this country.

The School of Forestry has been greatly assisted by Lord Cowdray, who has offered ample facilities for the practical study of forestry in his woodlands, which cover some seven square miles of country in Sussex. The research hospital is being used for the treatment of wounded officers under the control of the Army Council, and some 300 patients have been already received. The pathological museum has been enriched by a collection of specimens illustrating the effect of gunshot and other wounds on the bones and soft tissues, the material having been provided by the 1st Eastern General Hospital.

THE annual meetings of the Geographical Association will be held on January 6 and 7, at University College, London. On the morning of January 6, the presidential address will be delivered by Mr. H. J. Mackinder, and afterwards a discussion on "The First Steps in Geography Teaching" will be opened by Miss E. G. R. Taylor. In the afternoon Dr. Marion Newbigin will lecture on "The Geographical Study of Rivers," and the lecture will be followed by a discussion on "The Use of Home-made Apparatus," which will be opened by Mr. E. J. Orford. On the morning of January 7 a joint meeting of the Geographical and Historical Associations will be held, to discuss "The Relations of Geographical and Historical Teaching in Schools." Mr. H. J. Mackinder and Prof. Ramsay Muir will open the discussion.

PRACTICALLY the whole of our engineering colleges have now overcome the early difficulties and opposition which attended the starting of making munitions and otherwise rendering assistance in the present

emergency, and are now showing a production of gauges, gun parts, etc., which many engineers unacquainted with the capabilities of college workshops and staffs have found difficult to credit. Colleges not making munitions are training workers for the new munition factories, and many have undertaken researches of various kinds. Some information regarding the work in progress will be found in a paper by Dr. Walmsley and Mr. Larard, read at the Institution of Mechanical Engineers on December 17. It is to be hoped that the closer connection which exists at the present time between colleges and engineering works will not be broken when the war is over. Each side has much to learn from the other, and it promises well for the future that old prejudices on both sides are fast disappearing.

IT is announced in the issue of *Science* for December 10 that Mrs. Russell Sage has given Syracuse University a fund to build a college of agriculture as a memorial to her father. The building is to cost several hundred thousand dollars, the exact sum to be decided later. Our contemporary also states that a new building will be constructed for the University of Illinois Medical School in Chicago for the clinical courses. The initial cost is to be about 20,000*l.*, which will pay for one wing. This will be added to later as the demand for room increases. From the same source we learn that the trustees of Delaware College have made plans for the expenditure of a gift of 100,000*l.* to the college by an unnamed donor. A report submitted by the chairman of the Plans and Development Committee, which has been approved by the board, shows that 50,000*l.* will be used for a science hall to house the agricultural and chemical departments, 15,000*l.* to remodel the old dormitory building and turn it into a commons for the students, and 40,000*l.* will be set aside for maintenance.

AMONG the resolutions passed by the Headmasters Conference last week was one moved by Mr. A. L. Francis, headmaster of Blundell's School, Tiverton, "That in the opinion of this conference very grave loss to the country is caused by the employment of young students of exceptional mathematical and scientific ability as subalterns in Line battalions." Several important questions are raised by this resolution, but the chief point put forward by Mr. Francis was that the country should not permit itself to be deprived of its most ingenious and inventive brains in the grim struggles of the battlefield. "The place for the young man who has a special gift for science, mathematics, or mechanics is in the laboratory." Everyone will agree with this in principle, but the practical difficulty in deciding what students are sufficiently endowed with a "special gift" to be husbanded for national work in science and invention is another matter. The young students to whom Mr. Francis seemed to refer were those of Public School age, but it may be doubted whether at such an early stage it is possible to distinguish the few original minds which are destined to create new knowledge. Success in examinations certainly does not provide a true standard by which this genius for productiveness in science and invention may be measured. What we all deplore, and think should be avoided, is the sacrifice of men like Capt. J. W. Jenkinson and Lieut. Moseley, who had shown exceptional ability as original investigators. Apparently the Headmasters Conference does not object to the young students embraced by the resolution becoming subalterns in corps of engineers and artillery, where there are opportunities of applying a knowledge of science and mathematics, or even in the guards or the cavalry, where there may be no such need. Hundreds of able students of mathematics and science from university colleges and technical schools are at present serving as privates and non-commissioned officers in the Army, and the rank offered by the War Office to exceptional men in such subjects as chemistry and mining is not usually that of a subaltern but of a corporal.

THE annual report of the Royal Technical College, Glasgow, for the session 1914–15, has reached us. The "Roll of Members, Students, and Past Students on the King's Service" forms an appendix of a hundred pages. The roll comprises eight members of the governing body and of committees, 37 members of the staff, 1152 students of 1914 and 1915, and 622 students of previous sessions. These are serving in the following capacities:—Officers, 490; non-commissioned officers, 351; men, 966; nurse, 1; and on special service, 11. The appointment of 114 naval officers from the School of Navigation is specially noteworthy. The report records the deaths of ninety-one whose names appear on the roll. The reduction in the normal work of the college is indicated by the following comparative table of the number of students who enrolled:—

	Day students	Evening students	Total individuals
1914–15	445	2583	3028
1913–14	669	4342	5011

These enrolments necessarily include the large number of students who offered themselves during the session for active service, or who received appointments under firms manufacturing munitions. Many former members of the staff and students of the department of chemistry are now engaged in this work, and this department has made a contribution of about 150 men to the corps of chemists attached to the Royal Engineers. There are usually about 150 day students at work in the chemical laboratory during the session, but in the last week this number had dwindled to four, while of ten assistants on the staff only two were left. The plans for the increase of the new endowment fund initiated to extend the facilities available for higher studies and for research work have necessarily been postponed, but a grant of 520*l.* from the Bellahouston Trustees towards this object is acknowledged in the report.

SOCIETIES AND ACADEMIES.

LONDON.

Geological Society, December 1.—Dr. A. Smith Woodward, president, in the chair.—Dr. J. W. **Evans**: Petrological methods. The different methods of obtaining the directions-image ("interference figures") of a small mineral in a rock-slice, unaffected by the light from neighbouring minerals, were discussed. The author prefers the use of a diaphragm in the focus of the eyepiece, in conjunction with a Becke lens; he also described the inferences that might be drawn from the form, position, and movement on the rotation of the stage of the isogyres (dark bars or bushes) in the directions-images, both of chance sections and of those cut parallel to planes of optical symmetry or at right-angles to optical axes. He showed how the character or sign of the crystal and its approximate optic axial angle might be determined.

Linnean Society, December 16.—Prof. E. B. Poulton, president, in the chair.—E. S. **Goodrich**: The reproduction of Protodrilus. The author criticised the account given by Prof. U. Pierantoni, according to whom there are in most species of the genus male and hermaphrodite individuals. Dr. Orton having recently discovered *Protodrilus flavocapitatus* at Plymouth, the author has been able to study large numbers at the Marine Biological Laboratory. The appar-