

metal or of the circulating water to carry off the heat. In many cases condensation was diminished by films of oil or grease, or by accumulations of hair, or by other incrustations or deposits, but these were not considered in the paper.

The authors found, on the contrary, as the result of their experiments on a steam-engine running under normal conditions, that a practically clean and dry metal surface was not immediately heated to the temperature of the saturated steam in contact with it, that the rate of condensation of steam was not infinite, but finite and measurable, and that the amount of condensation in any given case was limited chiefly by this finite rate of condensation, and could be calculated in terms of it.

The cyclical variations of temperature in the metallic walls of the cylinder, with each stroke of the engine, were measured by means of thermo-couples inserted at various distances from the inner surface. It was possible thus to deduce the amount of heat absorbed and given out by the metal, and to infer the quantity of steam condensed and re-evaporated at different points of the stroke. The temperature-cycles of the steam were simultaneously measured by a very sensitive platinum thermometer. The observations showed that the temperature of the steam in different parts of the cylinder differed in a systematic way from the saturation temperature as deduced from indicator diagrams.

In order to deduce the condensation from the observed temperature-cycles, it was necessary to determine the conductivity and specific heat of cast iron. A series of experiments were made upon a four-inch bar of cast iron, and the result found for the conductivity was nearly 30 per cent. smaller than that generally assumed.

At the lowest speed of the experiments, namely, forty-five revolutions per minute, the temperature of the surface of the metal at the end of the admission period was found to be never raised higher than within  $20^{\circ}$  F. of the temperature of the steam, and the rate of condensation at any moment was simply proportional to the difference between the temperature of the steam and the surface. The numerical value found for the rate of condensation was  $0.74$  B.T.U. per second per square foot of surface per degree Fahrenheit of difference between the temperature of the steam and the surface. This was equivalent to the condensation of 27 pounds of steam per square foot per hour at  $300^{\circ}$  F., for a difference of temperature of  $10^{\circ}$  F. Assuming this law, the total amount of condensation at any point of the stroke could be inferred by measuring the "Condensation Areas" on the temperature-cycle diagram, *i.e.* the areas included between the curves representing the temperatures of the steam and of the metal surface.

To compare the results thus found with the missing steam deduced from the indicator diagrams and the feed measurements, the leakage of the valve and piston was determined as nearly as possible under the conditions of running. It was found to be proportional to the difference of pressure and nearly independent of the speed through a considerable range. The usual test for leakage with the valve stationary was found to be of little or no value. From a comparison of leakage tests, it was inferred that a valve in motion, however well fitted, was subject to leakage of a definite type. The leakage took place chiefly in the form of water, by condensation and re-evaporation on the moving surfaces, and was directly proportional to the perimeter of the ports and inversely to the width of the bearing surfaces. The amount of condensation observed during the admission period in a single-acting non-condensing cylinder 10.5 inches in diameter with a stroke of 12 inches, was only 20 per cent. of the feed at a speed of 100 revolutions per minute. The smallness of this result was probably due to the early compression and the dryness of the steam supply. It was found that re-evaporation was completed very quickly, and that the walls were dry for the greater part of the cycle. It was inferred from the form of the temperature curves and from other evidence that the rate of re-evaporation was the same as that of condensation.

From the form of the law of condensation it was possible to make an important theoretical deduction with regard to cases in which re-evaporation was incomplete, and the walls remained wet throughout the whole cycle. Under these conditions the mean temperature of the walls should be the same as the time average of the temperature of the steam to which they were exposed, and the cyclical condensation was the maximum possible for the given steam cycle. If the extent of the clearance surfaces was known, this limiting value of the condensation in any case might be easily deduced from the indicator diagram.

If the surfaces were dry during part of the stroke, the condensation was less than the limit, and it was necessary to know the mean temperature of the clearance surfaces in addition. Upon these views of the nature of condensation and leakage, the missing quantity of steam  $W$  in pounds per hour might be expressed by an equation of the general type,  $W = S (t' - t'') + L (p' - p'')$ ,—where the first term represented condensation and the second term leakage,  $S$  being the equivalent clearance surface in square feet, and  $t' - t''$  the mean difference of temperature, in degrees Fahrenheit, between the walls and the steam during admission reduced to one-half cut-off.  $L$ , the rate of leakage per pound difference of pressure  $p' - p''$ , might be taken to vary approximately as the product of the diameter and the square root of the normal piston-speed, for engines of different sizes. It would appear from this formula that the effect of leakage on the performance was relatively more important in small engines and at high pressures, and that the loss due to condensation was most effectively reduced by increase of piston-speed.

As an indirect verification of this law of condensation, the temperature of the clearance surface in cases in which water was present in the cylinder was measured, and was found to agree with that of the mean of the steam cycle. The amount of condensation was also correctly calculated in several cases of published tests in which sufficient data were available. The rate of condensation deduced was also directly verified by an entirely different method. The experiments gave approximately the same rate of condensation, and appeared to show that the water-drops condensed on the metallic surface, owing probably to their rapid action, did not appreciably diminish the rate. Assuming it possible to estimate the condensation occurring in any given case by the method indicated, from a knowledge of the indicator diagram and of the temperature and area of the clearance surfaces, it then became possible to determine the amount of leakage under the actual conditions of running.

#### UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The Institution of Civil Engineers has resolved to exempt Bachelors of Arts who obtain honours in the Mechanical Sciences Tripos from the examination prescribed for the Associate Membership of the Institution.

The Managers of the John Lucas Walker Studentship have elected Mr. J. W. W. Stephens, of Caius College, to the studentship in Pathology, and Dr. Hamilton K. Wright, of McGill University, Montreal, to an Exhibition of the value of 50*l*.

The proposal to authorise the Examiners for the Natural Sciences Tripos Part II. to inspect the laboratory note-books of candidates for honours was carried in the Senate by forty-seven votes to eighteen.

Dr. H. A. Giles has been elected to the Professorship of Chinese. Dr. W. H. R. Rivers, of St. John's College, has been appointed University Lecturer in Physiological and Experimental Psychology. Mr. W. L. H. Duckworth, Fellow of Jesus College, has been recognised as a Lecturer in Anthropology.

The Walsingham Medals for research in Biology, including Physiology, have been awarded to Mr. V. H. Blackman, of St. John's College, and Mr. W. M. Fletcher, of Trinity College. The electors report that the essays of four other candidates were of a high order of merit.

The election to the Isaac Newton Studentship in Astronomical Physics will be held in the Lent Term 1898. Candidates must be Bachelors of Arts of less than twenty-five years of age on January 1. The studentship is of the value of 200*l*. a year for three years. Applications are to be sent to the Vice-Chancellor between January 14 and 24.

The University delegates to the International Congress of Hygiene at Madrid, next April, are Dr. Kanthack, Dr. D. MacAlister, and Dr. Anningson.

THE death is announced of Dr. Brownless, Chancellor of Melbourne University.

DR. H. H. HOFFERT has been promoted to a senior inspectorship under the Science and Art Department, and Mr. S. J. Cartledge—at present head-master of the Hanley School of Art—has been appointed to the vacant inspectorship.

THE London Technical Education Board will proceed in July next to award three junior scholarships in practical gardening, which will be tenable at the new School of Practical Gardening which has recently been opened at the gardens of the Royal Botanic Society in Regent's Park. This school has been established with the view of providing a complete course of instruction for lads who desire to become gardeners. The scheme of work, which has been drawn up by the Royal Botanic Society, combines thorough practical instruction in all the operations of gardening with theoretical instruction in botany and the nature of soils and manures. The course is arranged so as to extend over three years.

THE list of entrance scholarships and exhibitions awarded at Pembroke, Gonville and Caius, King's, Jesus, Christ's, and Emmanuel Colleges, Cambridge, affords an indication of the comparative encouragement given to classics and science at the University. It appears from the list that the scholarships for classics have the value of 1360*l.* Mathematics comes second with scholarships amounting to the value of 640*l.*, and the natural sciences take the last place with scholarships having a total value of 390*l.* Considering that the Science Tripos is the largest, or nearly the largest, this seems a discouraging division of the scholarship fund. It is only fair to add that at Trinity and St. John's Colleges the authorities are far more liberal to science, the value of scholarships awarded for natural sciences at the former College being 330*l.*, and at the latter, 205*l.*

THE *Times* of Monday contains a detailed report of a conference held on Saturday last at the rooms of the Society of Arts, Adelphi, to consider the expediency of further development in the constitution of the Royal Holloway College in the light of the founder's expressed desire that powers should ultimately be sought enabling the college to confer degrees on its students. Mr. Bryce, M.P., one of the governors of the college, presided, and there was a large and influential gathering of educationists. Papers were read by Mr. R. D. Roberts in favour of an application from Holloway College for a separate charter to enable it to confer degrees upon its students; by Mr. Strachan Davidson, of Balliol College, Oxford, in support of the establishment of a women's university, of which Holloway College should form a part; and by Mrs. Bryant in advocacy of the proposal that Holloway College should become an integral member of the new teaching University of London. A number of letters from prominent educationists were read, expressing their views on the subject. A discussion followed, in which Mrs. Henry Fawcett, Miss Emily Davies, Mrs. Sidgwick, of Newnham, Miss M. Gurney, Sir Joshua Fitch, Mr. H. Sidgwick, and others took part. There was a practical consensus of opinion against the proposal that Holloway College should give degrees; a great majority of the speakers were opposed to the creation of a separate University for women, and many of them were in favour of connection with the new London University.

THE new Academic Hall of Edinburgh University, opened on Saturday last, is another testimony to the close and friendly connection which has always existed between the University and the city. In 1888, Mr. William M'Ewan, M.P. for the Central Division of Edinburgh, offered a sum of 40,000*l.* with which to build the Academic Hall, which had formed a part of the original plans of the new University buildings, which had already cost 250,000*l.* to complete. This offer Mr. M'Ewan afterwards, on its being made clear that the amount was inadequate if the hall was to be proportionate to the buildings already erected, agreed to increase to 62,000*l.*, which was the original estimate of the cost of the hall. As the scheme grew under the hands of the architect, artificers, decorators, and organ builders, the liberality of Mr. M'Ewan kept pace, and the hall, as it now stands completed, has cost him 115,000*l.* The gift is a noble one, and it provides a noble example of the interest which the citizens of Edinburgh take in the welfare of the University. In accepting the deed of conveyance, on behalf of the University, Mr. Balfour said: "I confess that I have seen with feelings of regret, sometimes almost amounting to shame, the extreme difficulty which there has been not merely in connection with Edinburgh, but in connection with other great seats of learning, to obtain from the liberality of a not illiberal public sufficient means to make our great British Universities all that British Universities should be. I fear that in this respect we can but ill stand comparison with our cousins of the United States. There, if my information is not incorrect, they have never failed to find men with the means and with the will to keep the institutions of

higher education in their country abreast with the ever-growing necessities of such institutions; and the number of generous benefactors which America has been able to show may well cause some feeling of shame, I think, in us on this side of the Atlantic, speaking the same language, possessing the same culture, aiming at the same objects, but who have not always shown in pursuit of those objects the same uninterested generosity. The relations between Edinburgh and the University, always close, almost always friendly, have not been diminished by changes in the status of the University. In connection with this very hall, or rather with the surroundings and accessories to the hall, the city of Edinburgh has shown itself possessed of the same generous public spirit, the same desire to do everything in its power to promote the interests of this great seat of learning which it has shown throughout all the centuries since this University was first founded." Mr. M'Ewan's liberality and Mr. Balfour's remarks upon the relations between the city of Edinburgh and the University should furnish food for reflection to the citizens of London.

THE *Technical Education Gazette* publishes a few particulars with regard to the entries in the various classes at the nine polytechnics which are in receipt of aid from the Technical Education Board of the London County Council. The most significant fact in connection with the polytechnics is that, notwithstanding the opening of four new large polytechnics during the four years that the Board has been at work, no diminution has been caused in the number of students attending the older institutions, but on the contrary, every one of the nine institutions shows an increase in the number of class entries for the present session. Thus the remarkable result has been brought about that, although these four new institutions show this session a total of over 8000 class entries, representing a total number of nearly 5000 individual students, yet the enrolment of these new students has not only not decreased the membership of the other older institutions but has actually stimulated their growth. It may be estimated that there are now in attendance at the evening classes of the nine polytechnics about 18,000 individual students, the great majority of whom are engaged in systematic courses of evening instruction under the direction of the principal of the institution where they are studying. If we take the class entries in detail according to the various branches of study, we find that the classes in the building trades show in almost every case an increase in the number of students. In the engineering trades there is likewise a very general increase in the attendance at the classes. The great demand that exists for evening instruction in electrical engineering is shown by the fact that in both the two polytechnics in the south-west district of London, the Battersea Polytechnic and the South-west London Polytechnic at Chelsea, the number of students has increased during the past year with remarkable rapidity. Another satisfactory instance of increase is shown in the classes in typography and letterpress printing. Perhaps the most remarkable fact of all is that the original polytechnic at Regent Street, which draws its students from all parts of the metropolis, and which might therefore have been expected to suffer from the growth of new institutions, continues not only to maintain its numbers but even shows a further increase on last year. Last year the number of individual students attending on November 1 was 5583; this year there were in attendance on November 1 as many as 5848, representing an increase of about 5 per cent. A very rapid development has taken place in the classes at the South-west London Polytechnic. So numerous are the entries this session for both the day and the evening departments, that the resources of the building are taxed to the utmost, and very serious inconvenience is being caused in some of the departments by the want of sufficient accommodation.

#### SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, November 18.—"Account of a Comparison of Magnetic Instruments at Kew Observatory." By Dr. C. Chree, F.R.S., Superintendent.

Last July, M. T. Moureaux, of the Parc Saint-Maur Observatory, near Paris, brought over to England the travelling instruments employed in his magnetic survey of France, and a comparison was made between these and the standard magnetic instruments at Kew Observatory.