and iron hail and iron rain, and so on, falling upon the photosphere as the rain falls on the earth. There is thus a possibility in the sun of home-made meteoritic action.

So far as my last course of lectures was concerned, I there ended that part of the subject. But so many points had been raised in trying to give a connected view of these two very slowly converging lines of research to which I referred, that, after the lectures were over, I determined to discuss the various points which had been raised. I determined to take up Prof. Tait's suggestion, and see how all the spectroscopic observations which had been made up to the time of my lectures in 1886, bore out that suggestion which had been made in 1871, before there was very much spectroscopic evidence to go upon. The result was that my assistants and myself spent something like three years in gathering together, we believe, every available observation; at all events, if not every available observation, there were between thirty and forty thousand of them, and we found that a very considerable number. I not only determined to collect them, but also to discuss them, and make any experiments or observations which might be suggested by the discussion. The result of this was that, as a fruit of that course of lectures, several papers, some of them very long—it is not for me to say anything as to their value—were sent in to the Royal Society, and eventually brought together in a book.

Now, what I found was that when we discussed the meteoritic view in the light of all the observations we could get together, and in relation to stars as well as nebulæ and comets, it seemed to explain many things, and threw a perfectly new light upon the visible universe; there were, moreover, several points raised of intense novelty and freshness, each of which could be discussed separately, cast aside if it were false, and held on to if it were true. I give a table of some of these new points of view.

New points of view in the Meteoritic Hypothesis.

(1) There is the closest possible connection between nebulæ and stars.

(2) The first stage in the development of cosmical bodies is not a mass of hot gas, but a swarm of cold meteorites.

(3) Many bodies in space which look like stars are really centres of nebulæ; that is, of meteoritic swarms.

(4) Stars with bright-line spectra must be associated with nebulæ.

(5) Some of the heavenly bodies are increasing their temperatures; others are decreasing their temperatures.

(6) Double swarms, in any stages of condensation, may give rise to the phenomena of variability.

(7) New stars are produced by the clash of meteor swarms. They are closely related to nebulæ and bright-line stars.

(8) Cosmical space is a meteoritic plenum.

(9) A new classification of the heavenly bodies, based on the varying states of condensation of the meteoritic swarms.

(10) The sun is one of those stars the temperature of which is rapidly decreasing.

(11) Many of the changing phenomena of the sun are due to the fall of meteoritic matter upon the photosphere.

We ultimately arrived at the conclusion that the sun is one of the stars, the temperature of which is gradually decreasing, and that many of the phenomena of the sun are due to the fall of meteoritic matter on the photosphere.

The doing of a large piece of work like that—and I say it is large because I am glad to have the opportunity here of expressing my gratitude to my assistants, who stood by me for three years—brings one out pretty well into the open, and renders one liable to a brisk fire of criticisms, some very valuable, some quite unworthy of the critics.

You will see that the work was undertaken with a view of determining the sun's place among the stars.

J. NORMAN LOCKYER.

(*To be continued.*)

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE annual general meeting of the Institution of Mechanical Engineers was held on Thursday and Friday evenings, the 31st ult. and the 1st inst. Prof. A. B. W. Kennedy, F.R.S., occupied the chair. There were two papers set down for reading and discussion:

"The Determination of the Dryness of Steam." By Prof. W. Cawthorne Unwin, F.R.S.

"Comparison between Governing by Throttling and by Variable Expansion." By Captain H. Riall Sankey.

Prof. Unwin, in his interesting paper, gave descriptions of the best known methods of determining the mean of moisture in steam up to now introduced. Most of the apparatus described was exhibited on the table of the theatre, whilst diagrams illustrative of them were hung on the wall. The author pointed out that the earliest attempts to determine the amount of moisture in steam, of which records have been found, were made during some boiler trials carried out by a committee of the Société Industrielle of Mulhouse in 1859. This committee tried three different methods—a method of separation, a condensing method suggested by Hirn, and a chemical method. In these early trials the condensing method only, in which the total heat of a sample of the steam was measured, appeared to give satisfactory results. But although the committee did not place full reliance on any of their methods, these have all been used by various experimenters down to the present time.

The origin of water entrained in steam, Prof. Unwin said, was to be attributed to three causes:

(1) Water projected into the boiler's steam space during ebullition. The extent to which wetness occurs depends on the activity of the ebullition, the area of the water surface, the volume of the steam space, the position of the steam valve, the density of the steam, and, probably more than anything else, on the quality of the water and its liability to produce foam. The author referred to the experiments of Mr. Thornycroft, who constructed a boiler with glass ends, through which the process of boiling could be seen. The result of observations on this boiler showed[1] that waters which cause priming produce foam on boiling. Water which is very bad produces bubbles so durable as to remain a considerable time without breaking; and by them the steam space of a boiler may be entirely filled. So soon as this takes place, instead of simply steam leaving the boiler, the discharge consists of foam, which becomes broken up in its rapid passage through the steam-pipe. With pure water, steam retains no film of liquid long enough to be seen.

(2) Water may be produced in steam from the expansions to which it is subjected. Fluctuations of pressure arise from the intermittent demand for steam, and from the steam passing from places of higher to places of lower pressure. Prof. Unwin considered it difficult to believe that any great amount of wetness arises in this way in ordinary cases.

(3) The steam in the boiler, and the steam-pipes, loses heat by radiation. Probably in some cases considerable wetness is produced in this way. The wetness of the steam, so far as it is due to this cause, will increase as the demand for steam diminishes.

The author next went on to deal with the various methods of determining the wetness of steam, referring first to the weighing method, by which a known volume is weighed, when any excess of weight above that of a corresponding volume of dry saturated steam must be due to the water present. This method is obviously one of excessive difficulty.

The superheating method was next referred to in the paper, the experiments of Barrus and Carpenter being quoted. The Carpenter calorimeter consists of a vessel about 12 inches high by 5 inches diameter, consisting of an inner chamber and a jacket. The steam from the steam-pipe passes first to the inner chamber, where the moisture is separated, and then into the outer chamber. The separating chamber is therefore perfectly protected from radiation. As the water accumulates in the inner chamber, its level is shown by a gauge glass, and the amount in hundredths of a pound can be read off on a scale. A very small orifice at the bottom of the outer chamber regulates the amount of steam discharged. The escaping steam passes through a flexible tube to a simple form of condenser. The increase of weight in any given time in the condenser is noted, and the amount accumulated in the same time in the separator.

The condensing method was next described. This is founded on the condensation of a known weight of steam and the determination of its total heat by the rise of temperature in the condensing water. By comparing the total heat per pound of a sample of steam with that of a pound of dry saturated steam according to Regnault's tables, the amount of moisture in the steam can be determined. This method was first suggested by Hirn, and the apparatus which he designed is perhaps the most

[1] "Circulation in the Thornycroft Water-Tube Boiler." *Transactions* of the Institution of Naval Architects, 1894.

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convenient form of apparatus for determinations by this method. It consists of an iron vessel about a foot in diameter, furnished with a loose cover; this forms the condenser. A small pipe and cock in the steam-pipe deliver steam through a small orifice near the steam pipe into another pipe, through which it passes into the condensing water. An agitator and a sensitive thermometer are provided in the condenser. For weighing the amount of steam condensed, the whole condenser is suspended from a hydrostat, which permits extremely accurate determination of any change of weight. The hydrostat is balanced by weights till the pointer is at a fixed mark before and after condensing the steam. The condensing method, the author said, is strictly accurate in principle, but difficult to carry out in a satisfactory manner. In order to overcome these difficulties a method of continuous condensation has been introduced. By this steam and cold water are both supplied at a constant rate, and the condenser acquires a steady temperature, which can be very accurately observed. A diagram of a continuous injection condenser was shown on the wall of the theatre. Steam passes from the steam-pipe to a small injector. The condensing water is drawn from a tank, and the mixed water and condensed steam are discharged into another tank. The two tanks are placed on platform weighing machines. Two thermometers give the temperature of the condensing water (the water used for condensing the steam), and of the mixture of condensed steam and condensing water. The difference of the total weight in the two tanks, after any interval of time, is the steam condensed in that time.

A superheating method, which was introduced about the year 1890, by Mr. G. Barrus, was next referred to by the author. The steam to be tested is passed through an inner chamber jacketed by superheated steam. The sample of steam to be tested was thus dried and superheated at the expense of heat borrowed from the jacket. To avoid measuring the steam, an attempt was made to secure that equal weights of steam passed through the inner chamber and through the jacket. In that case the wetness of the steam can be calculated from observation of the temperatures only. The method, the author said, is accurate in principle, but appears to be difficult to carry out satisfactorily.

The wire drawing calorimeter was next described. This and the separating method the author considers most nearly fulfilled the necessary conditions requisite for measuring the quantity of moisture contained in steam. This calorimeter consists of two chambers, steam passing from the first to the second through an aperture $\frac{1}{16}$ inch in diameter. The full steam pressure is in the first chamber, and the pressure in the second differs little from atmospheric pressure. Thermometers give the temperatures in the chambers (which are protected from radiation), and in this way the quantity of water present in the steam is estimated. The steam is allowed to flow through the apparatus for twenty minutes or more, when the temperatures become nearly steady. No weighing is required, and temperatures only have to be observed. The observations can be continued as long as desired, so as to obtain a mean value for the dryness fraction from a considerable quantity of steam. If the steam is very wet, the temperature in the second chamber falls to about 212°, showing that wire-drawing to atmospheric pressure is insufficient to dry the steam. Practically the instrument cannot be used if the wetness exceeds the values given in the following table, the pressures being in lbs. per square inch, and the atmospheric pressure being assumed at 14·7 lbs.

Initial pressure (absolute).	Initial pressure (gauge).	Initial temperature F.	Initial wetness per cent.
29·9	15·2	250°	0·80
67·2	52·5	300°	2·44
135·1	123·4	350°	4·21
247·7	233·0	400°	6·13

Two conditions are necessary for accuracy in using this method. The second chamber must be large enough for the eddies to die out before the steam leaves the chamber. Radiation must be so far prevented that the steam in the chamber is not sensibly cooled. A calorimeter by which the separating and wire-drawing methods were combined was also explained by the author. This is the globe calorimeter which is a well-arranged apparatus.

The Cummins superheating method was also described. A vessel is filled with the steam to be tested, and then heated by a jacket. As it is heated, the rise of pressure in the inner vessel is observed, the volume being constant. So long as the steam is moist, the pressure will rise with the temperature according to the law for saturated steam. The moment all the moisture is evaporated, the rate of rise of pressure with temperature will become much slower.

The well-known salt test was next alluded to by the author. This, however, he pronounced to be inconvenient and untrustworthy, excepting perhaps in the case of a boiler subject to marked priming action.

The general conclusion drawn by the author was that the wire-drawing calorimeter without separator is the most convenient and accurate for steam with less than about 2 per cent. of moisture. For steam containing more moisture, the separating calorimeter without wire-drawing apparatus is accurate enough and convenient. The use of the separator and wire-drawing calorimeter combined is more troublesome, especially if, as is desirable, a condenser is also used to determine the amount of steam passing through the separator. In cases where there is much priming, it would seem best to take the whole of the steam through an ordinary steam-separator, measuring the amount of water trapped, and then to test by a wire-drawing or separating calorimeter the dryness of the steam after passing the separator. With priming much of the water probably flows along the bottom of the pipe, and it appears impossible that a sample can be obtained containing an average proportion of steam and water. It is recommended by Prof. Carpenter that the sample of steam to be tested should always be taken from a vertical, not from a horizontal steam-pipe. No doubt there is rather more tendency for water to flow along the bottom of a horizontal pipe than down the sides of a vertical pipe; but merely taking steam from a vertical pipe does not ensure freedom from error, especially if the amount of moisture in the steam is considerable. Variations in tests for wetness are doubtless often due to the difficulty of getting a true average sample of steam; and it would seem that errors are generally in the direction of under-estimating the amount of moisture.

A long and interesting discussion, which was adjourned from the Thursday until the Friday evening, was held on Prof. Unwin's paper. The chief point touched upon was the method to be adopted in getting a true sample of steam for analysis. This undoubtedly is the great difficulty that has to be overcome before a satisfactory method of determining the amount of moisture in steam can be arrived at. The majority of speakers were of opinion that water entrained in the steam would hang to the sides of the pipe, and a good many suggestions were made with a view to shifting the collecting nozzle over the whole area of the cross-section of the pipe, or else to give such an orifice to the nozzle as would cover a large part of the pipe area.

In his reply to the discussion, Prof. Unwin explained that this did not seem to him the true light in which the problem should be regarded. With steam rushing through a pipe at high speed, eddies would be set up which would be sufficient to thoroughly mix the steam and water so that there would be a fairly homogeneous mixture. The true difficulty arose from the checking of the velocity of the steam at the collecting orifice, an action which resulted in water accumulating so that an excess of moisture was shown in the sample drawn off. In order to overcome this, he had devised a collecting nozzle consisting of a bent-over tapered pipe, the orifice of which was at the small end, and was pointed towards the flow of steam. By adopting the necessary dimensions for the collecting nozzle, the steam collected would not be checked in velocity at the collecting orifice, and therefore moisture would not be deposited at that point.

Captain Sankey's paper was one of considerable length, and although dealing with one point only of engine design, was of great interest to engineers. It was illustrated by a large number of diagrams hung on the wall of the theatre. Without these it would be extremely difficult to give a fair idea of the course of reasoning followed by the author in discussing the merits of the two systems of governing engines. The paper, as the author said, was an elaboration of one section of a paper contributed to the Institution of Civil Engineers by the late Mr. Willans.

Speaking broadly, it may be said that the author's opinion was that the popular verdict in favour of variable expansion governing may for many purposes be accepted, yet its advantages were commonly much overrated, and in some cases it had no advantage at all.

It would be impossible within the limits of our report to trace out the respective merits of the use of the throttle valve and

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automatic expansion gear, under the many conditions of working which the author supposes; and as the discussion on the paper was adjourned until the next meeting, we may leave the subject for the present.

The summer meeting of this Institution will be held in Glasgow this year, commencing Tuesday, July 30, and concluding on the following Friday.

THE ADVANCE OF TECHNICAL EDUCATION.

THE present state of technical education in England is, on the whole, satisfactory from the scientific point of view. The authorities having the funds arising from the Customs and Excise Act under their control, are beginning to see that instruction in the principles of science is by far the most important of the requirements. They are also coming to recognise that immediate results cannot be expected from their work—that they are laying a foundation rather than erecting a complex edifice. The Technical Instruction Committees who have not sufficiently realised this, will find that they will have to materially modify their at present too ambitious schemes, postponing much of the instruction in subjects of technology until a more thorough acquaintance with the fundamental principles of science underlying all such purely technical education has been provided, for it is only by such means that the stability of their educational superstructure can be ensured.

There are no grounds, therefore, for taking a pessimistic view of the future of technical instruction. One of the most gratifying signs of development is the large number of scholarships now awarded, and the increase in the number of competitors for them. The current number of the *Record* of Technical and Secondary Education sets forth in detail a statement as to the scholarships and exhibitions actually awarded, during the year 1893-4, by County and County Borough Councils. This most valuable Return shows the number of scholarships and exhibitions awarded; the value and length of tenure of the awards; where held; conditions to be fulfilled by the candidates; the examining body, and the subjects of examination. Subjoined is a summary of the information.

Scholarships and Exhibitions tenable at	No. of Councils.	Scholarships and Exhibitions. Number awarded.	Total yearly value.
			£
(1) Technical, and Science and Art Schools	36	3456	10,620
(2) Secondary Schools	37	1789	20,409
(3) Universities or Institutions of University rank	28	362	6,783
(4) Short courses of instruction	25	561	3,825
		6168	41,637

Sixty individual counties and county boroughs are represented in the above summary. Two others, Derby and Sheffield, allocate respectively £325 and £1000 annually to scholarships, and taking these into consideration, it appears that the total sum expended for the promotion of technical and secondary education by scholarships, during the year ending March 1894, was, in round numbers, £43,000. But this by no means represents the limits of expenditure under the scholarship head. It does not take the renewal of scholarships into account, and there are still seven local authorities whose scholarship schemes have not come into operation. Also, the scholarship schemes will undoubtedly be further developed as the work goes on; in fact, it is estimated that before very long as much as £30,000 will be spent annually on scholarships by the London Technical Education Board alone. Truly, these are halcyon days for the promising young student, however humble his state of life may be.

As to the values of the scholarships, they vary from a few shillings, as a fee for a short course of instruction, to £60 a year tenable for three years. The lower limit of age is usually thirteen, and the higher, twenty-five, though we see no reason why such a maximum age should be made absolute. In some cases, the income of the parents of competitors must not exceed £400 a year, but in others—London is the most notable instance—the parents of competitors for junior scholarships must not be in receipt of more than £150 a year.

Another important statement in the current *Record* shows the plans for promoting technical and secondary education in each of the counties and county boroughs of England. From this it appears that, of the 110 local authorities in England, 96 are giving the whole, and 13 part of their grants to educational purposes. Preston is the remaining authority, and it devotes the whole of the grant available—about £1600 per year—to the relief of the borough rate. But it should be stated at once, that Preston possesses a well-endowed "Harris Institute," where technical education has been carried on for years. The total amount available by local authorities is about £744,000, of which about £144,000 is diverted to the relief of the rates, leaving £600,000 for expenditure on education. We are sanguine enough to believe that, before long, most of the £144,000 at present devoted to general county purposes will be expended in advancing technical education. London alone is responsible for £114,000 of this misapplied balance, but as its educational scheme matures, it will doubtless absorb the whole amount available. It is to be hoped that the authorities applying the remaining £30,000 to rates, will soon see how detrimental their action is to their own interests.

In this connection it is necessary to condemn the application to rates of any unexpended balance of the grant available. In every county and county borough there are persons who utterly fail to realise that the interests of science are the interests of industry. To them, immediate advantages in the shape of a minute reduction of the rates, appeals far more than prospective developments of our national industries. Had such people the control of affairs, technical instruction would indeed be curtailed within narrow limits. Fortunately, they represent but a small minority in the County Councils; nevertheless, their influence is occasionally manifest. Ever since the Technical Education Acts came into force, attempts have been made here and there to use for general county purposes the funds available and necessary for education. But if the work is to be successfully carried out, it is essential that the Technical Instruction Committees should have entire control of the grants allocated to technical education. There is far too much uncertainty about the grants even now, and the County Councils which are inclined to exercise a veto as to the destination of the surplus funds of their Technical Education Committees, will soon find that self-respecting members of the Committees will retire from the work. Recently, however, one or two Councils have shown their incapacity to understand the magnitude of the problem before them, by voting the unexpended balance of their grants to the relief of rates. This action is tantamount to declaring that the funds at the disposal of the Committee are in excess of what is required; whereas, it is hardly too much to say that additional secondary schools are needed in almost every county and county borough in England, only to mention one way in which the money might be expended. For the balance to be diverted from education is bad enough, but no great foresight is needed to see that, once the action has been taken, there is no knowing where or when it will stop. Perhaps the county of Hampshire is the most notable instance in which a County Council has crippled the work of its Technical Instruction Committee. In November last, according to the *Southampton Times*, the Council resolved to appropriate, for general purposes, £6000 from the surplus funds which had been accumulated by the Technical Instruction Committee with the idea of eventually using it in educational developments. Without taking the views of the Committee into consideration, the Council appears to have calmly confiscated the balance resulting from economical administration, and by so doing not only discouraged careful expenditure, but in one fell swoop rendered the Committee powerless to deal in the future with matters which alone could be met by exceptional means. Surely it is not too much to expect a Council to have confidence in the ability of the Technical Instruction Committee, and to allow it to know its own needs. At any rate, a Committee whose opinion is disregarded must soon lose confidence in itself. It is a matter for congratulation that County Councils generally have not treated their Committees in the same way as the elect of the county of Hampshire.

One of the most refreshing reports we have seen for some time has recently been issued by the Derbyshire County Council. The report is satisfactory, not so much on account of work accomplished, but because it affords evidence that the Committee seems to have been brought to a good understanding as to what technical instruction should mean. One of the chief difficultie

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