very suggestive; it is to be regretted that one of the supporters has gone; with it in position and the quoit removed we have a great similarity to the leading feature in the Aberdeen circles, namely, a recumbent stone between two uprights. The similarity to a cove is also obvious.

NORMAN LOCKYER.

HELIUM.

A LITTLE more than ten years ago this remarkable element was only known to astronomers through the medium of the spectroscope. Now it is not only to be found in all laboratories, but appears to occur in almost all constituents of the earth's crust and in amounts proportional to their radio-activity, except in beryl (Strutt). In some cases it occurs in quantities far from minute, as in certain minerals, particularly cleveite and monazite, where the number of litres of gas obtained is comparable with the number of kilograms of mineral treated. Again, it constitutes more than 5 per cent. of the gases evolved from some mineral springs, as at Maizières, and 1·84 per cent. of the vast supplies of natural gas at Dexter, Kansas, while it occurs everywhere as four parts in a million of the atmosphere (Ramsay). Its mode of occurrence and origin are too complex and still too uncertain to be treated adequately here, but it is apparently not liberated from minerals by grinding alone to an impalpable powder (Moss), and it certainly permeates quartz at temperatures above 220° C., and with a velocity rising with the temperature (Jaquerod and Perrot). Moreover, it appears to be frequently produced in the gradual breaking down of the uranium molecule and the various radio-active transformations of this into radium and other substances.

Helium was first known from its yellow line D_3 , and was first detected on the earth by the same characteristic (Ramsay). In nitrogen or hydrogen it appears that a proportion of 10 per cent. can just be detected by its spectrum (Collie and Ramsay). Very shortly it was shown to be a very light, unreactive gas with monatomic molecules. Hence it was taken to be the lightest known member of the argon group. Later determinations have shown that its density cannot differ much from 2·0 (Onnes), and that the value of the ratio of its specific heats is 1·63 (Geiger), which confirms the earlier results.

The very simple character and small mass of the molecule are evident in all its properties; thus its refractivity $(n-1)$ is found to be very small, but various observers differ as to whether there is dispersion in the visible spectrum or not. Recent results give values of $3·478 \times 10^{-5} + 7·6 \times 10^{-16}/\lambda^2$ (Burton), and $3·47 \times 10^{-5} + 8·2 \times 10^{-16}/\lambda^2$ (Cuthbertson and Metcalfe), in excellent agreement for a value about one-quarter of that of hydrogen and with considerable dispersion. Measurements on the conductivity for heat $K=f\eta C_v$ show that it is greater than for other gases, and appear to indicate that f has its theoretical value of 2·5. They are, however, complicated by the uncertainty as to the value of η , the viscosity. The viscosity with reference to air is given as 0·96 (Rayleigh). The diffusion of helium through a porous plug is faster than the simple theory would indicate (Ramsay and Collie), and this, together with the want of conformity in effusion results, may be partially due to its very low inversion temperature (Donnan).

The same characters are obtained under the influence of electric stimulus; thus ionic velocities of 6·31 cm./sec. for negative and 5·09 for positive α rays (Frank and Pohl) are larger values than those found for any gas but hydrogen. In the vacuum tube the dark space

exhibits several distinct maxima showing long free paths (Aston).

The Zeeman effect is extremely simple and regular, the lines breaking up into normal triplets with dispersions $(d\lambda/\lambda^2)$ proportional to the fields up to 12,000 c.g.s. (Lohmann). Confirmatory observations with measurements of e/m give values of this for D_3 ($\lambda=5876$) of $11·3 \times 10^6$ across and $12·3 \times 10^6$ parallel to the field, somewhat higher values being found for two other strong lines, $\lambda=6678$ in the red and $\lambda=5016$ in the blue-green (Grey and Stewart).

Gaseous helium has a small negative magnetic susceptibility of 0·00175, less than argon (Tänzler), while its dielectric cohesion is the lowest known. All monatomic gases have low values, argon being 39 where hydrogen is 205, but helium is 18·3, so that 0·005 per cent. of the diatomic gas can be clearly detected (Bouty).

It would seem as if this property might be a certain and easily applied method of checking the freedom of helium from hydrogen. Other methods of testing its purity are determinations of density and spectrum analysis. The former is extremely accurate when great precautions are taken, but does not easily give an accuracy of more than 0·05 per cent.; however, with the spectroscope it seems that 0·008 per cent. or less of hydrogen can be seen (Onnes).

It is, however, in its character of the most perfect known gas that helium has the most obvious usefulness, and this in two directions. At all temperatures below 100° C. a constant-volume helium thermometer is the most convenient and accurate known because the corrections are very small and regular. Determinations of the mean pressure coefficient from 0° C. to 100° C. gave values of 0·00366241 and 0·00366270 for a normal thermometer (760 mm. at 0° C., Travers and others). These values, when corrected and re-calculated to the international scale (1000 mm. at 0° C.), appear as 0·0036616 and 0·0036613, the former of which agrees exactly with a direct determination at this pressure (Onnes). To obtain these corrections use has been made of isotherms observed at 0° C., 20° C., and 100° C., and the corrections of the helium thermometer to the absolute scale are deduced from isotherms at the values given. They are $-0·006$ at $-103·57$ C., $+0·002$ at $-182·75$ C., and $+0·01$ at $-216·56$ C., while in later measurements of the boiling point $+0·2$ is assumed at $-268·6$ C. = $4·5$ K., if absolute zero = $-273·10$ C. (Onnes). The isotherms indicate that there is no minimum until about -253 ° C., so that the Boyle point, where $(d(pv)/dp)_t=0$, appears to lie at about this temperature, and hence the Joule-Kelvin inversion temperature, for small pressure differences, will lie at about twice this, or 40° K. The isotherm for $-258·82$ exhibits a distinct minimum at about 10 atmospheres, as can be seen by plotting the following values for pv against p ; $p=0$, $pv=0·05222$; $p=40·012$, $pv=0·06150$; $p=46·222$, $pv=0·06559$; $p=53·326$, $pv=0·07063$; $p=58·797$, $pv=0·07531$.

The value of the critical temperature, which had been variously given from 8° K. (Dewar) to 2° K. (Olszewski), and about 1° K. (Onnes and Keesom), was settled by these isotherms as not greater than 5·3 K., and later observations of the liquid fixed it as little above 5° K. with a correspondingly low critical pressure of 2·3 atmospheres (Onnes). Liquid helium boiling normally at 4·5° K. is very mobile, with an extremely small apparent surface tension and a density of 0·15, and is only eleven times denser than the vapour above it (Onnes).

In mixtures of helium and hydrogen the gaseous helium sinks in the liquid hydrogen at about 40 atmospheres (Onnes), which opens up a wide field of

theoretical and practical investigation. The value of b , in van der Waals's equation, was assumed to be 0.0005 with a negligible a (Onnes and Keeson), and this is in agreement with the value of 0.000432 calculated from the isotherms at and above -217° C. (Onnes). From the observations on the liquid, however, it would seem that the value of b should be 0.0007 there, and that a must have a positive value of 0.00005 (Onnes). Lastly, the lowest steady temperature known was obtained by boiling helium at a pressure of not more than 1 cm., at which the temperature could not have been much above 3° K. The liquid was mobile and perfectly clear, and no trace of solid was visible, so that a still lower steady temperature is clearly attainable (Onnes). FRANCIS HYNDMAN.

THE INTERNATIONAL CONGRESS ON ROADS.

THE first International Road Congress was held in Paris during the week which ended on Saturday last, October 17. On the whole the congress may be pronounced a success, chiefly on account of the large number of interested visitors present, and from the fact that on certain points there was a strong consensus of opinion that roads can now be constructed to stand modern automobile traffic at slight additional cost, and that the two nuisances dust in summer and mud in winter can be greatly minimised in their extent.

The congress, though not wholly official, received the support of the French Government. The letters of invitation and explanatory circulars were sent out from the general secretary of the Ministère de Travaux publics; consequently the invitations were not confined to delegates sent by the Governments of the various countries represented, but were sent to representative public bodies, road authorities, automobile clubs, and to engineers and other members of the public who are likely to have knowledge and be interested in the great question of road communications.

The attendance at the meetings was generally very good; the rooms were crowded. As is usual, the hospitality shown by the French in the way of *fêtes* and excursions made the week very enjoyable to the French provincial visitors as well as to the foreign visitors. The first reception was at the Sorbonne, afterwards a grand evening reception at the Hôtel des Invalides, a gala performance at the Comédie Française, and a final sitting at the Sorbonne on Saturday morning announcing the results obtained.

The general procedure was as follows. Early in the year requests were sent to all the interested countries that contributions should be submitted in the form of short papers, which would be printed and circulated previous to the congress, the substance of which would be collected by a reporter of each of the groups, and on which discussions would take place. The subjects on which these memoirs were invited were the following:—General reports on the construction and maintenance of existing roads, special reports on the cost of road-bed and methods of construction of roads; special reports on maintenance questions—on this group of construction and maintenance of roads thirty-two papers were received, of which seven were by English contributors.

The second group of questions related to that part of road construction and maintenance which was rightly named at the congress "the present struggle against the wear and the dust." These included methods of cleaning and washing, and questions were specially put asking for experience in the use of tar or similar insoluble binding materials. Twenty-two papers were received in this group, five of them by English authors. Another group was on the roads of

the future. On this question fifteen papers were received, none of them by English authors.

The remaining questions were those relating to traffic, damage caused to the roads by speed or by the weight of the vehicles, by pneumatic tyres, anti-skidding devices and similar matters. To this question sixteen papers were specially addressed, half of them by Englishmen. Then came seven papers, all by Frenchmen, on road signalling and milestones; and finally six papers on public vehicles used on the roadway, including tramway services. Five of these were by Frenchmen and one by a Spanish engineer.

Altogether ninety-eight papers were contributed, printed and circulated previous to the congress to all the subscribing members. This part of the work was splendidly done. The papers were sent in in their original language; in many cases they were completely translated; in some cases summaries were made in more than one language. It will be seen that about one-fifth of the whole of the papers came from England.

The discussions were divided into two sections, first those chiefly relating to road construction, and second those relating to the use of the roads and the vehicles running on them. They were held in the old tennis court at the corner of the Tuileries Gardens next to the Place de la Concorde, and on the plateau immediately surrounding this building were grouped a large number of modern appliances used on the roads, such as road rollers, road repairing machines, machinery for brushing and watering by horse-power and by automobile power, and, lastly, a long array of machines for distributing tar or other bituminous compounds on the road to render it waterproof and dustless. Inside the building a number of smaller exhibits were shown of various road materials and specimens cut out of existing roads, the latter being chiefly found on a collective English exhibit.

As stated at the commencement of this article, the success of the congress laid chiefly in the interest which it excited, and in the fact that for the first time a large number of road engineers and of those interested in the use of roads were brought together in a very pleasant manner, and, as is usual at these meetings, a great many useful friendships were formed which will undoubtedly lead to the better circulation of new ideas on road construction.

The number of English professional visitors was very large. Among the English visitors were found chairmen of the county councils, many of the most prominent county engineers, with a large sprinkling of municipal men and of surveyors of the various rural districts. As might be expected, a very considerable number of these gentlemen were not sufficiently familiar with French to follow the debates, which for the most part were conducted in French.

At an early stage it became evident that the knowledge possessed by some of the English visitors was very valuable to the congress, but that there was a great risk of their experience being lost, so that it was decided to hold supplementary meetings of the English-speaking, *i.e.* the English and American, visitors, previous to the regular meetings, and this course, although at first sight it might have seemed as if the English-speaking races wished to be exclusive, turned out to be of use. The results of the discussions by the English-speaking sections were delegated to one or two speakers, who afterwards communicated them during the main debates. In this way some useful resolutions were carried which cannot now be given, as they were not printed or agreed to in detail when the writer left Paris immediately after the final sitting on Saturday; but, speaking generally, it may be said that a great many of