a minute it was there; then it came out and flew away. Burning with curiosity, I hurried into the garden, and, eagerly parting the branches of the hedge, looked into the nest—and lo and behold, there, lying in Henrietta's dear little cup-shaped, softly lined cradle, I saw the cuckoo's egg! One of my sisters had watched the whole affair with me, and once more we were amazed at the positively uncanny sagacity of the bird. The whole thing seemed so extraordinarily intelligent and so *mean.*"

The observer noticed that the cuckoo had not her egg in her bill, and concluded that it was in its mouth out of sight. But might not the cuckoo lay the egg in the nest? The hedge-sparrow laid four eggs, and when the young cuckoo was hatched the usual tragedy occurred. "For the first two days his shiny naked little body was dark fawny-pink in colour, but by the fourth day he had gone almost black, and his eyes, covered over with blue-black skin, looked disproportionately large. From the moment that his eyes opened he showed signs of surprising viciousness whenever I put my hand anywhere near the nest." When the young cuckoo was a fortnight old, more than filling the nest, the foster-mother was seen brooding, "uncomfortably crouched on top of his broad and ample back. It was rather like a pigeon trying to brood a hen." Whenever either of the foster-parents approached, the young cuckoo made a "strange little tinkling noise, . . . just like a tiny tinkling silver bell." The menu consisted of grubs, daddy-long-legs, butterflies, caterpillars, and small insects, and the number collected and consumed in a day was amazing. The indefatigable foster-parents continued to feed the cuckoo for more than a week after it had left the nest.

Miss Terras tells her story in a very attractive way. We do not know whether she has done this by instinct or by art, but we know we have had a most delightful hour. We recommend the book very strongly to young people and to those who would renew their youth.

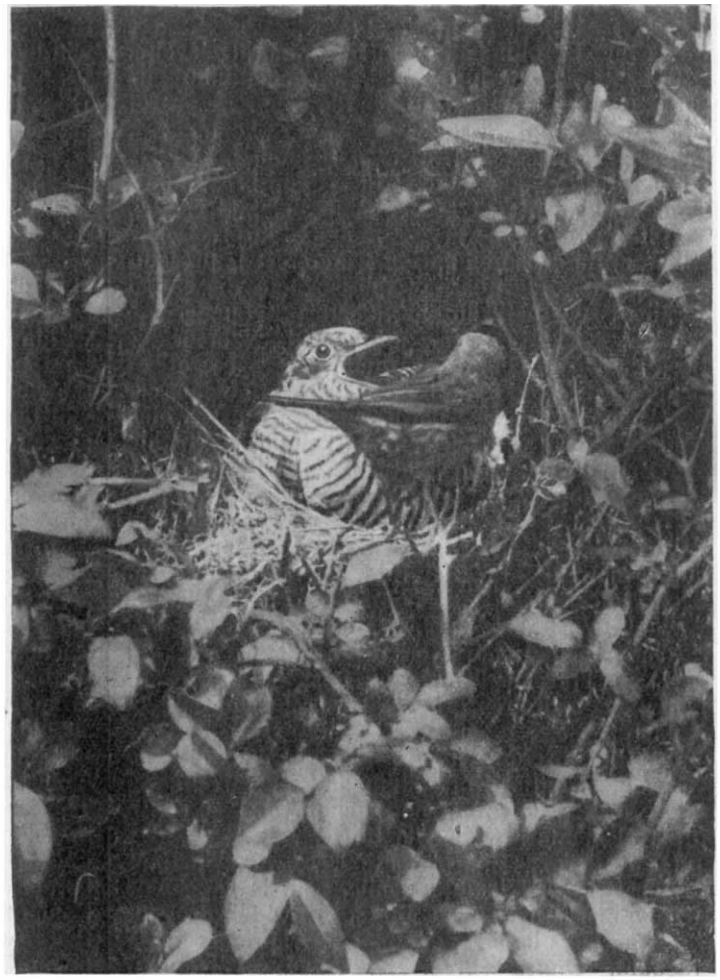

FIG. 2.—Hedge-sparrow feeding a young cuckoo. From "The Story of a Cuckoo's Egg."

Helium: Its Production and Uses.[1]

By PROF. J. C. McLENNAN, F.R.S.

IN 1868 Janssen (*Compt. rend.*, 1868, vol. lxvii., p. 838) directed attention to the existence of certain lines hitherto unobserved in the solar spectrum, which we now know are given by the element helium. In the same year Frankland and Lockyer[2] (Proc. Roy. Soc., 1868, vol. xvii., p. 91), from their observations on these spectral lines, were led to announce the existence of an element in the sun which up to that time had not been found on the earth. To this element they gave the name "helium."

In 1882 the discovery was made by Palmieri (*Gazzetta*, 1882, vol. xii., p. 556) that the helium spectrum could be obtained from rocks and lavas taken from Vesuvius.

In the United States of America, Hillebrand in 1890 (Bull. U.S. Geol. Survey, 1890, No. 78, p. 43) succeeded in obtaining a quantity of gas

[1] From a lecture delivered before the Chemical Society on June 17.
[2] See NATURE for May 20, p. 361.

from the mineral uraninite, which from chemical and spectroscopic tests he concluded was nitrogen. This gas, we now know, was, in fact, helium.

Finally, in 1895, Sir William Ramsay (*Chem. News*, 1895, vol. lxxi., p. 151) discovered that a gas could be obtained from the mineral cleveite. This gas he purified, and, on examining its spectrum, he found it to be the long-sought-for element helium. From 1895 up to the present, investigation has shown that helium is widely diffused throughout the earth. It can be obtained from many types of rocks, minerals, and earths, and it is present in varying amounts in practically all natural gases and spring waters. It is present, too, in the atmosphere of the earth to the extent of about four parts in one million by volume.

The gases from some springs in France have been shown to contain as much as 5 per cent. of helium. In the Western States of America, especially in Texas, natural gases exist which contain from 1 to 2 per cent. of helium, but within the British Empire no natural gases which have been examined show a helium content as high as 0·5 per cent.

Until the spring of 1918 not more than 3 or 4 cubic metres of helium had, in the aggregate, been collected, and its market price, though variable, was about 300*l.* per cubic foot.

The principal characteristics of helium are:

(1) Its extreme lightness. It is only twice as heavy as hydrogen, the lightest element as yet isolated.

(2) Its absolute inertness. All attempts to effect combinations of helium and the rare gases, neon, argon, krypton, and xenon, as well, with other elements have as yet failed.

(3) Its close approximation to an ideal or perfect gas. It is monatomic, and is liquefiable at a temperature below that of liquid hydrogen. By causing liquid helium to evaporate in a vacuum, Onnes (Proc. K. Akad. Wetensch. Amsterdam, 1915, vol. xviii., p. 493) has succeeded in reaching a temperature within 1° or 2° of the absolute zero.

(4) Its low sparking potential. Electric discharges can be passed through helium more easily than through most other gases.

No element has had a more romantic history than helium, and none is of greater interest to men of science than is this gas at the present time. Its formation as a disintegration product of the radio-active elements, and the identity of the nuclei of helium atoms with α-rays, give it a unique position among the elements.

Intense interest has been aroused by Sir Ernest Rutherford's recent discovery that in the nuclei of helium atoms in the form of α-rays we have a powerful and effective agent for disintegrating and simplifying the nuclei of atoms generally. This discovery points the way to still further progress. In the past helium has been considered a rare and precious gas. To-day it is being produced in large quantities, and in view of the proposal now being put forward to use this gas in place of hydrogen as a filling for airships, one is apt to consider it to be not so precious as heretofore. It may be, however, that such vast and vitally important directions will suddenly be opened up in which helium can be utilised that the conservation of the gas, while it is still available to us, will become a matter of the first importance.

Shortly after the commencement of the war in 1914, it became evident that if helium were available in sufficient quantities to replace hydrogen in naval and military airships, losses in life and equipment would be very greatly lessened.

The fact that helium is both non-inflammable and non-explosive, and possesses 92 per cent. of the lifting power of hydrogen, makes it a most suitable filling for airship envelopes. By the use of helium the engines of airships can be placed within the envelope if desired. A further advantage possessed by helium over hydrogen is that the buoyancy may be increased or decreased at will by heating or cooling the gas by electric or other means, which fact may possibly lead to considerable modifications in the technique of airship manœuvring and navigation. Moreover, the loss of gas from diffusion through the envelope is less with helium than with hydrogen to the extent of about 30 per cent.

Although there are indications that proposals had been put forward during the war by men of science in Allied and enemy countries, as well as in the British Empire, regarding the development of supplies of helium for aeronautical purposes, it should be stated that the movement that led up to the investigation which it was my privilege to undertake was initiated by Sir Richard Threlfall. The existence in America of supplies of natural gas containing helium in varying amounts was known to him and others, and preliminary calculations as to the cost of production, transportation, etc., which he made led him to believe that there was substantial ground for thinking that helium could be obtained in large quantities at a cost which would not be prohibitive.

Sir Richard's proposals were laid before the Board of Invention and Research of the British Admiralty, and in the autumn of 1915 the author was asked by that Board to determine the helium content of the supplies of natural gas in Canada, and later on of those within the Empire, to carry out a series of experiments on a semi-commercial scale with the helium supplies which were available, and also to work out all technical details in connection with the production of helium in quantity, as well as those relating to the re-purification, on a large scale, of such supplies as might be delivered and become contaminated with air in service. The present paper aims at giving a brief account of this investigation.

Composition of the Natural Gases Investigated.

In commencing the investigation, a survey was made of all the natural gases available in larger or smaller quantities within the Empire with the view of ascertaining their helium content. Natural gases from Ontario and Alberta, Canada, were found to be the richest in helium, and these sources, it was found, could supply from 10,000,000 to 12,000,000 cubic feet of helium per year. The following is a summary of the results obtained from the analyses of a number of the gases investigated. They include, it will be seen, a few samples from outside the Empire. For a complete account of this part of the investigation, the reader is referred to Bulletin No. 31 of the Mines Branch, Department of Mines, Canada, 1920.

(*a*) *Ontario Gases.*—The analysis made by Profs. Ellis, Bain, and Ardagh (Report of Bureau of Mines of Ontario, 1914) of the natural gases supplied to the experimental station, initially set up at Hamilton, Ontario (Blackheath System), is as follows:—

Methane	80 per cent.
Ethane	12 „
Nitrogen	8 „

It was found, however, on operating with this gas that the percentage assigned to methane really included a considerable proportion of gasoline, pentane, and butane as well. The helium content of the gas was found to be 0·34 per cent.

(*b*) *Alberta Gases.*—Gas taken from the mains leading from the Bow Island supply to Calgary was found to be quite free from the heavier hydrocarbons. At times it contained slight amounts of water vapour and occasionally a trace of carbon dioxide as well. Its approximate composition is given under I.

	I.	II.
Helium	0·33 per cent.	0·36 per cent.
Methane	87·6 „	91·6 „
Ethane	0·9 „	1·9 „
Nitrogen	11·2 „	6·14 „
Carbon dioxide ...	trace	trace
Water vapour ...	trace	trace

One well in particular, namely, No. 25 Barnwell, which has recently been driven, and now supplies gas to the system, was found to have a product of the composition II.

(*c*) *New Brunswick Gases.*—Some natural gases obtained from wells struck near Moncton, New Brunswick, Canada, were examined, and found to have the following composition:

Methane	80·0 per cent.
Ethane	7·2 „
Carbon dioxide...	None
Oxygen	None
Nitrogen	12·8 per cent.
Helium	0·064 „

(*d*) *New Zealand Gases.*—A series of samples of the natural gases from the Hanmer, Kotuka, Weber, Blairlogie, and Rotorua supplies in New Zealand was forwarded by Mr. J. S. McLaurin, Dominion Analyst of Wellington, New Zealand, for examination, but was found to have an insignificant helium content, the richest containing not more than 0·077 per cent.

(*e*) *Italian Gases. Pisa.*—A sample of the natural gas brought by pipe to the city of Pisa, in Italy, was examined, and found to have the following composition:

Methane	80·0 per cent.
Ethane	4·0 „
Carbon dioxide	3·5 „
Nitrogen	11·9 „
Oxygen	0·6 „
Helium	None

(*f*) *Miscellaneous Analyses.*—An analysis of the natural gas supply from Heathfield, Sussex, England, showed it to have a helium content of but 0·21 per cent. The gas from the King Spring, Bath, England, was found to contain 0·16 per cent. of helium, and analyses of natural gases obtained from Trinidad and from Peru showed their helium content to be negligible. An interesting observation was made in connection with natural gases obtained from Pitt Meadows, Fraser River Valley, and Pender Island, in the Gulf of Georgia, British Columbia. Both these gases were found to have a nitrogen content of more than 99 per cent.

Preliminary Experiments.

Soon after taking up the investigation, it was found, as mentioned above, that large supplies of helium were available in the natural gas fields of Southern Alberta, and that a small supply could be obtained from a gas field situated about twenty-five miles to the south-west of the city of Hamilton, in Ontario. In 1917 the Board of Invention and Research decided to endeavour to exploit these sources of supply, and operations were begun by setting up, as already stated, a small experimental station near the city of Hamilton.

At this station efforts were directed towards constructing a machine which would efficiently and economically separate out the helium from the other constituents present in the natural gas. The carrying out of this work expeditiously was made possible through the hearty co-operation of L'Air Liquide Société of Paris and Toronto, which generously lent, free of cost, a Claude oxygen column and the necessary auxiliary liquefying equipment for the investigation.

By making suitable additions to, and modifications in, this oxygen rectifying column, it was ascertained that the problem of separating, on a commercial scale, the helium which was present in this crude gas to the extent of only 0·33 per cent. was one capable of satisfactory solution. Early in 1918 it was found possible to raise the percentage of helium in the gas to 5·0 by passing it through the special rectifying column once only, and as the gas obtained in this way consisted of nitrogen and helium with a small percentage of methane, it became therefore a comparatively simple matter to obtain helium of a high degree of purity. In one particular set of experiments on this final rectification, helium of 87 per cent. purity was obtained.

Experimental Station at Calgary, Alberta.

In order to operate on the natural gas of the Bow Island system in Southern Alberta, an experimental station was established at Calgary in the autumn of 1918, and, starting with the knowledge acquired through the preliminary operations at Hamilton, rapid progress was made in developing a rectification and purifying column, together with the requisite auxiliary equipment, which would efficiently and cheaply separate the helium from the natural gas.

Development of the Rectification Column.

In proceeding to develop an equipment for separating the helium from the other constituents of natural gas, three lines of attack appeared to be open, namely, (*a*) by producing the refrigeration necessary to liquefy all the gases except the helium by the cold obtainable from the natural gas itself, (*b*) by using external refrigeration entirely, such as that obtainable with ammonia, carbon dioxide, liquid air, liquid nitrogen, etc., and (*c*) by combining methods (*a*) and (*b*).

The last method had been successfully used for the production of helium by the naval authorities of the United States in the Texas field, but from the information supplied it did not appear that this process could be considered to be an economical one.

The preliminary experiments at Hamilton, Ontario, made it abundantly clear that method (*a*) was very promising and likely to be both efficient and economical. This method was therefore adopted. It was evident from the start that to produce an efficient method the main difficulty to overcome would be the securing of a proper balance between the heat exchangers, the liquefier, the vaporisers, and the rectification portions of the machine. A machine was therefore designed, constructed, and supplied with piping which possessed great flexibility, and, in its general scheme, followed the lines of the Claude oxygen-producing column. It is unnecessary to go into details regarding the operation of this machine. It will suffice to say that it was tested under a variety of conditions. Notes were taken of the temperatures reached at different points in the machine under equilibrium conditions when the gas was passed through it in various ways. As a result of this procedure, it was soon found what parts of the machine could be eliminated and what parts could be modified with advantage. When those changes were made which seemed desirable in the light of the experience gained, it was found that a machine had been evolved which would give highly satisfactory results.

In operating with this machine, it was found that helium of 87 to 90 per cent. purity could be regularly and continuously produced.

Operations.

The experimental machine just described was used continuously for a series of trial runs from December 1, 1919, to April 17, 1920. In making a run, about 500,000 cubic feet were passed through the machine, and from this amount upwards of 20,000 cubic feet of the gas, containing 5 to 6 per cent. of helium, were obtained. As this low-grade product was made it was stored in a large balloon, and the residual gas was passed back into the mains for use in the city of Calgary. The 5 to 6 per cent. product was compressed to from 20 to 30 atmospheres, and then passed through vaporisers. The amount of final product, of 87 to 90 per cent. purity, obtained in each run rose steadily in the course of the operations from about 300 cubic feet to more than 700 cubic feet per run. From this it will be seen that the efficiency obtained with each of the two operations was about 67 per cent. In special runs made under exceptionally good conditions a still higher efficiency was obtained. One of the curves given in Fig. 1 shows that the purity of the high-grade final product was steadily maintained in the series

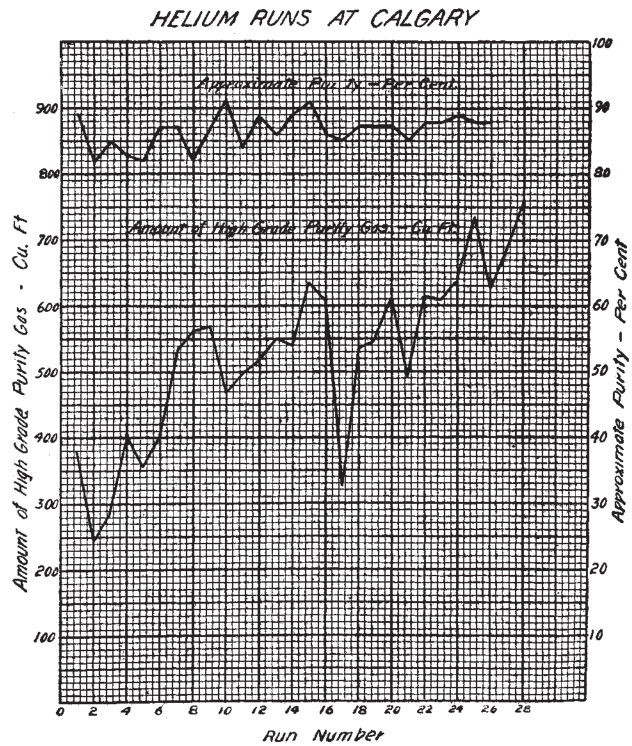

FIG. 1.

of runs, and the other curve exhibits the steady increase made in the production of helium of high-grade purity.

High-grade Purification.

When it was seen that the highest purity obtainable with the experimental machine under actual running conditions was about 90 per cent., steps were taken to design and construct an auxiliary piece of apparatus for raising the purity of the gas up to 99 per cent. or higher. This apparatus as constructed could be used, not only for obtaining a product of high purity at the works, but also for purifying helium which became contaminated with air by use in balloons in service. Through numerous delays experienced in obtaining delivery of tubing, liquefying equipment, etc., this purifying apparatus has not been given any more than a preliminary trial. From this, however, it is quite evident that it will prove satisfactory in operation. For the purpose of carrying out this scheme of high-grade purification, a liquid-air plant was installed by the University of Toronto. Motors and an electric current supply were furnished by the Hydro-Electric Commission of Ontario, and a special financial grant was made by the Honorary Advisory Council for Scientific and Industrial Research of Canada to supplement that made by the Admiralty and the Air Board of Great Britain.

Final Design of Helium-extracting Apparatus.

Every step in the production of high-grade helium has been carefully examined and tested. From the experience gained, we have been able to draw up specifications for a commercial plant which will enable one to treat the whole of the natural gas of the Bow Island supply in Alberta. The unit proposed will deal with about 1600 cubic metres or 56,500 cubic feet of gas per hour at normal pressure and temperature. At the altitude of Calgary, this would be equivalent to 62,200 cubic feet per hour. The machine would easily cope with 66,000 cubic feet per hour or 1100 cubic feet per minute. Of these machines, six would deal with 9,500,000 cubic feet of gas per day, and would thus take about the average daily supply available from the field, as based on records of the average yearly consumption. In order to have sufficient machines to operate regularly to capacity, it would probably be advisable to have eight helium columns included in the plant.

The cost of a commercial plant suitable for treating the whole of the supply of the Alberta field would probably be less than 150,000*l.* The amount of helium of upwards of 97 per cent. purity obtainable per year from the field would be about 10,500,000 cubic feet. This is based on the assumption of an efficiency of 80 per cent., which experience has shown is obtainable. As to operating costs, our experience has shown that, allowing for interest on the investment, a ten years' amortisation, salaries, supplies, and running charges, helium can be produced at the Alberta field for considerably less than 10*l.* per 1000 cubic feet. This sum does not, of course, include the cost of purchasing cylinders or of transporting them from and to the works. Neither does it include any compensation to the owners of the field for the supply of gas.

(*To be continued.*)

Obituary.

PROF. JOHN PERRY, F.R.S.

THE death of Prof. John Perry on August 4, at the age of seventy, leaves a blank in our scientific circle which cannot well be filled. A man of original mind and original manner, a warm-hearted Protestant Irishman, impulsive and enthusiastic in whatever cause he might engage, simple-minded to a degree and a thorough-going optimist, one of the most delightful of companions, he was of the class of lovable men and popular accordingly; he will be much missed, particularly at meetings of the British Association, of which he had been the general treasurer of late years.

Perry was educated in Belfast, finally at Queen's College, where he came under Andrews, one of the ablest and most original men of his day; it was from Andrews that he imbibed his feeling for chemistry, unusual in the engineer and mathematician: at least, he learnt to appreciate the part played by the electrolyte in chemical interchanges—as he once told me, through having fused out the bottom of Andrews's platinum crucible by heating potash in it. Later he was an assistant to William Thomson (Lord Kelvin). Under the influence of two such men his genius could not but unfold.

Perry began his career at Clifton College. I first met him at Clifton, at a dinner, where, of course, he out-talked everyone: I can well recollect how he amused us and how he called Sir Walter Scott an upholsterer. He was always a voracious novel-reader and remembered what he had read in an extraordinary way. On the occasion of the British Association visit to Winnipeg, he often astonished his travelling companions by his local knowledge, as he identified spot after spot with Fenimore Cooper's characters.

From Clifton, Perry went to Glasgow to assist Thomson, I imagine on Andrews's recommendation. In 1875 he went to Japan and was one of the band who gave the Japanese their first lessons in science—to be cast off when done with; like Ayrton and Divers, however, he was an ultra-enthusiastic Japanophile. In Japan he became associated with Ayrton and a constant flow of communications, mainly on electrical subjects, to the Royal and other societies was the consequence of the partnership. In those days what Ayrton and Perry did not know or do or claim to have done was not worth knowing, doing or claiming; no two men, in the exuberance of their youth, were ever better satisfied with themselves. They were in remarkable contrast: entirely diverse yet complementary natures, each cognisant and respectful of the other's special ability. Ayrton was the worldly, practical member of the firm, Perry the dreamer. Ayrton always had a sense of what was wanted and what would pay: he, I believe, usually set the problem; Perry worked out a solution, which Ayrton then criticised and referred back to Perry for development. In the same manner, I believe, he cooperated, during the war, with the mechanical genius of Sidney Brown—the husband of his niece—in the development of the gyrostatic compass.