Helium: Its Production and Uses.[1]

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II.

Miscellaneous Investigations.

IN the course of the investigation on the development of a machine for extracting helium from natural gas, supplies of helium of varying degrees of purity became available. These were highly purified, and used for the investigation of certain collateral problems which demanded solution. Among the results obtained, it was found that for aeronautical purposes hydrogen could be mixed with helium to the extent of 15 per cent. without the mixture becoming inflammable or explosive in air. Mixtures containing even as much as 20 per cent. of hydrogen could be burnt or exploded only when treated in an exceptional manner. The permeability of rubbered balloon fabrics for helium was shown to be about 0·71 of its value for hydrogen. For skin-lined fabrics, the permeability to hydrogen and helium was about the same. Thin soap films were found to be about one hundred times more permeable to hydrogen and helium than rubbered balloon fabrics, but untreated cotton fabrics when wetted with distilled water were but feebly permeable to these gases. It was found that rapid estimations of the amount of helium in a gas mixture could be made with a pivoted silica balance, a Shakspear katharometer, or a Jamin interferometer.

The latent heats of methane and ethane have been determined, as has also the composition of the vapour and liquid phases of the system methane–nitrogen. It has also been shown that helium containing as much as 20 per cent. of air, oxygen, or nitrogen can be highly purified in large quantities by simply passing it at slightly above atmospheric pressure through a few tubes of coconut charcoal kept at the temperature of liquid air. In the spectroscopy of the ultra-violet helium has been found to be exceptionally useful. Arcs in helium between tungsten terminals can be easily established and maintained. In a particular investigation with a vacuum grating spectrograph, it was found that by the use of arcs in helium under 30 cm. pressure illumination could be maintained continuously for hours, and with such arcs spectra could easily be obtained extending to below 1000 A.U.

Although it is known that free electrons can exist in highly purified helium to an amount easily measurable, it was found that pure helium under a pressure of more than 80 atmospheres did not exhibit anything in the nature of metallic conduction. Moreover, the mobilities of both positive and negative ions formed by α-rays in helium under this high pressure were found to have about one-third the value expected on the basis of an inverse pressure law.

[1] From a lecture delivered before the Chemical Society on June 17. Continued from p. 751.

The Uses of Helium.

The investigation into the problem of producing helium in large quantities was originally undertaken with a view to the utilisation of the gas in aeronautical warfare. The investigation has shown that it can be produced at a cost which is not excessive, but it has also been shown that from the sources in the Empire which are known and have been examined the supply of helium cannot be greater than about 12,000,000 cubic feet per year. This quantity clearly would be sufficient to keep only a very few of our airships of the larger type in commission, even if the gas were diluted to the extent of 15 per cent. with hydrogen. This amount would, however, suffice to keep a number of the smaller aircraft supplied. Moreover, it might be used to fill fireproof compartments adjacent to the engines if it were ever decided to install these within the envelopes of our larger airships.

Since it has been demonstrated that helium can be produced in quantity, one is led naturally to consider in what directions one can hope to use the gas other than that originally intended. In industry it may be used as a filling for thermionic amplifying valves of the ionisation type. It may also be used for filling tungsten incandescent filament lamps, especially for signalling purposes where rapid dimming is an essential, and for producing gas arc lamps in which tungsten terminals are used, as in the "Pointolite" type. Both these varieties of lamp possess the defect, however, of soon becoming dull owing to the ease with which incandescent tungsten volatilises in helium and deposits on the surface of the enclosing glass bulbs. As regards illumination, helium arc lamps possess an advantage over mercury arc lamps in that the radiation emitted has strong intensities in the red and yellow portions of the spectrum.

It has been shown by Nutting (*Electrician*, March, 1912) that Geissler tubes filled with helium are eminently suitable, under certain conditions, for light standards in spectrophotometry, but the amount of the gas which could be used in this way is very small.

In spectroscopy, especially for investigations in the ultra-violet region, helium is invaluable. Doubtless its use in this field will be rapidly extended. The use of the gas in physical laboratories generally, and especially where certain investigations on the properties of matter are carried out, will also be greatly increased.

It has recently been proposed to use helium in place of oil for surrounding the switches and circuit-breakers of high-tension electric transmission lines. If the gas should prove suitable for this purpose, large quantities could be utilised, but it has yet to be demonstrated (and it is not clear

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that it can be) that in this field helium possesses any advantage over the oils now used.

It has been suggested by Elihu Thomson and others that if divers were supplied with a mixture of oxygen and helium, the rate of expulsion of carbon dioxide from the lungs might be increased, and the period of submergence as a consequence be considerably lengthened.

It is probable, however, that in the field of low-temperature research helium will immediately find its widest application. For this work helium is unique in that, when liquefied and possibly solidified, it enables one to reach the lowest temperatures attainable. Every effort should be exerted towards the exploitation of its use in this direction.

One point that is important and should not be overlooked is that the supplies of natural gas from which helium can be extracted are being rapidly used up. When our natural gas fields are depleted it would appear that our main source of supply of helium will have disappeared. Careful consideration should, therefore, be given to the problem of producing helium in large quantities while it is still available, and of storing it up for future use. As already stated, it may be that in the future it will be of paramount importance to have even a moderate supply of the gas available.

A Cryogenic Laboratory.

To chemists and physicists especially, the discovery that helium can be produced in quantity at a moderate cost opens up a vista in the realm of low-temperature research of surpassing interest. By means of liquid oxygen, the properties of substances can be studied down to a temperature of -182.5° C. Liquid nitrogen provides us with a temperature of -193.5° C., and hydrogen, which was originally liquefied in 1898 by Sir James Dewar, enables us to reach -252.8° C. It is but a few years since Onnes, after prolonged effort, secured sufficient helium to enable him to liquefy this gas, too. In a brilliantly conceived research he succeeded in accomplishing this feat in 1908, and in doing it reached a temperature within approximately 1° or 2° C. of the absolute zero.

The amount of liquid helium which Onnes obtained in his investigation was small, but it sufficed to enable him to show that a number of the elements possessed a remarkable "super-conductivity" at this low temperature. Mercury in particular, at the temperature of liquid helium, possessed an electrical conductivity ten million times greater than at ordinary room temperature, and currents started by induction in a coil of lead wire at the temperature of liquid helium maintained their intensity for more than an hour with but little diminution in magnitude.

The results obtained by Onnes, although limited in number, are of great importance, for they show that if liquid helium were rendered available in quantity, fundamental information of the greatest value on such problems as those connected with electrical and thermal conduction, with specific and atomic heats, with magnetism and the magnetic properties of substances, with phosphorescence, with the origin of radiation, and with atomic structure, could be obtained.

In spectroscopy supplies of liquid helium would enable us to extend our knowledge of the fine structure of spectral lines, and thereby enable us to obtain clearer ideas regarding the electronic orbits existing in the atoms of the simpler elements. This would lead naturally to clearer views on the subject of atomic structure generally.

In other fields, too, important information could be obtained by the use of temperatures between that of liquid hydrogen and that of liquid helium. What of radio-activity? Would this property be lost by uranium, thorium, radium, and other similar elements at temperatures attainable with liquid helium? Would all chemical action cease at these temperatures? Would photo-chemical action disappear completely? Would photo-electric action cease or be maintained at such low temperatures?

In the fields of biological and botanical research, information on problems pressing for solution could be gained also. For example, would all life in spores and bacteria be extinguished by subjecting them to temperatures in the neighbourhood of absolute zero?

The list of problems rendered capable of attack by the use of liquid helium might be easily extended; but those cited already will serve to show that the field is large, and that it is well worth while for us to make a special effort to secure adequate financial support for the equipment and maintenance of a cryogenic laboratory within the Empire.

It is probably beyond the ordinary resources of any university to equip and maintain such a laboratory; but the project is one which merits national, and probably Imperial, support. It should appeal to private beneficence as well, for it is a project deserving strong and sympathetic help.

A properly equipped cryogenic laboratory should include:

(1) A liquid-air plant of large capacity.
(2) A liquid-hydrogen plant of moderate capacity.
(3) A liquid-helium plant of small capacity.
(4) Machine tools, cylinders, glass apparatus, measuring instruments, etc.

Such an equipment would probably cost more than 10,000*l.*

For building purposes, probably an additional 10,000*l.* or 15,000*l.* would be required.

The staff should include one or two skilled glass-blowers, two or three mechanics and instrument-makers, and two or three helpers for running the machinery. To provide this staff and meet charges for light, heat, and power, probably 3000*l.* a year at least would be needed.

For an administrative and technical staff, probably 2500*l.* would be necessary.

In addition to the above, special provision would have to be made to secure an adequate supply of helium. If industrial uses can be found for helium and a works were established in

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Alberta for the production of helium on a large scale, the problem of supply would be solved, for the amount of the gas which would be required for low-temperature research would probably not be more than 20,000 or 30,000 cubic feet a year. In default of a production-works on a large scale being established, it would be necessary to install a small plant at Calgary for the specific purpose of supplying the cryogenic laboratory with helium. This could easily be done at the present time, as the experimental plant is still *in situ*. It would require from 3000*l.* to 4000*l.* to make the changes in the plant which experience has shown are necessary, and to provide the additional auxiliary machinery, tools, etc., required.

If this plant were run for three or four months each year, an adequate supply of helium could be obtained. The expense of running the plant under these conditions would be high, and it would probably be found that it would require from 2000*l.* to 3000*l.* to operate it for a period of three or four months each year. This amount would, of course, have to cover charges for salary of staff, compensation to the owners of the natural gas, light, power, miscellaneous supplies, freight charges on cylinders, etc.

From the above it will be seen that a scheme such as that outlined would require in the aggregate a capital expenditure of about 30,000*l.* for buildings and plant, and the interest on an endowment of about 125,000*l.* for operating and maintaining the cryogenic laboratory, together with the supply station.

If a cryogenic laboratory, with its auxiliary supply station, were established along the lines indicated, it would probably be found to be more economical to run the supply station continuously for a number of years, and to store for future use the helium accumulated. In this connection it should be stated that the experimental plant as it exists would probably not produce more than 100,000 cubic feet of helium per year. The plant could, however, be easily manifolded, and the Governments of Great Britain and Canada might, from the point of view of national safety, legitimately be asked to assume responsibility for operating it.

Much of our knowledge acquired in the field of low-temperature research we owe to the brilliant work of such distinguished men as Andrews, Davy, Faraday, and Dewar. The discovery of the rare gases, helium, neon, argon, krypton, and xenon, we owe to Lockyer, Rayleigh, Ramsay, and Dewar. How could we more fittingly perpetuate the work of these great men than by establishing on a permanent basis a cryogenic laboratory for the purpose of making still further progress in the field of low-temperature research—a field in which British men of science have made such brilliant and notable advances?

The Cardiff Meeting of the British Association.

IT is twenty-nine years since the Association met in Cardiff. It is safe to say that any members who may have been present on that occasion will not now be able to recognise the city, for there can scarcely be any other town in the country which has not merely grown, but also altered, so much in that period. In 1891 there was on the north side of what is now one of the main streets a large tract of finely timbered ground called Cathays Park, adjacent to Cardiff Castle and its park, and also the property of the Marquess of Bute. In Cathays Park now stand a number of large and handsome public buildings, including the City Hall, Law Courts, University College, Technical College, and the National Museum of Wales. These are the buildings in which the meetings of the Association will take place, and not one of them was in existence at the time of the former meeting.

As usual, it is difficult to estimate the probable success of the meeting from the point of view of numbers, but locally every effort is being made to ensure it, and a good average meeting is expected. It is certain that the Association can never have been better provided in the matter of meeting rooms and lecture halls. The local arrangements are now almost complete. The housing shortage, particularly serious in Cardiff, and the fact that this is the holiday season have made the task of the rooms and hospitality committees rather trying, but it has been accomplished, and ample accommodation will be available.

The reception room, general offices, post office, and luncheon and tea room are situated in the City Hall; Sections A, F, H, and L meet in the University College; Section G has the use of the South Wales Institute of Engineers close by; and all the other sections are accommodated in the Technical College. In the Technical College also there is an assembly hall for special meetings. The inaugural general meeting, evening discourses, and citizens' lectures take place in the Park Hall, which is near one corner of Cathays Park.

Regarding the programmes of the individual sections, little can be added to the account of them published in NATURE of July 15. The journal of sectional and other proceedings will be ready on the first day of the meeting, but has lost its right to the name, for it will not be published daily as hitherto. Members should therefore retain their copies throughout the meeting. Any alterations in the sectional programmes will be shown from day to day on the notice board in the reception room.

The inaugural general meeting will take place on Tuesday, August 24, in the Park Hall, at 8 p.m., when the president, Prof. W. A. Herdman, will deliver his address. On Wednesday there will be a reception by the Lord Mayor of

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