ment monopoly, could in cases of advantage be partly transferred to air routes. Speed may in time be increased in two ways—first, by the improvement of ground organisation, so as to permit night flying with a relay system; and secondly, by improvement of the engine.

Sir Frederic Sykes quotes some remarkable figures to show the comparatively small risk in flying. During the last eight months of 1919 the total mileage flown by the principal firms engaged in civil aviation was 593,000, and the passengers carried totalled 64,416. During this period only four pilots and one passenger were killed, and six pilots and ten passengers injured. This small proportion of casualties will no doubt be reduced as machines are perfected, ground organisation improved, and air surveys carried out. The close association of the Meteorological Office with the Department of Civil Aviation is a happy augury for the future, and the International Air Convention, to which most of the Allies, and several neutrals, have subscribed, should help to co-ordinate efforts in civil aviation.

The consideration of good landing-places to a large extent controls the course of air routes. From Egypt the route to India is direct from Kantara to Damascus and Baghdad, thence to Basra, Bushire, and along the shores of the Persian Gulf and Arabian Sea to Karachi. Through India two routes to Calcutta are suggested—a northern one *via* Delhi, Cawnpore, and Allahabad, which is part of the route to Australia; and a southern one by Ahmadabad, Bombay, and Nagpur. On both routes aerodromes are already built or under construction, and there is now an aerial postal service between Karachi and Bombay. The Australian route from Calcutta goes *via* Akyab to Rangoon, whence a stretch of hazardous flying over mountainous country leads to Bangkok. The route continues *via* Singapore, Java, and Dutch Timor to Port Darwin. The latter stages of the journey offer difficulties in suitable landing-places. Alternative routes are proposed, and have been partly surveyed, and it is even suggested that the use of Dutch territory might be avoided by a route from Singapore to Australia *via* Christmas Island. This would entail two stages of 810 and 950 miles respectively, to say nothing of the possible difficulties of aerodrome construction on Christmas Island.

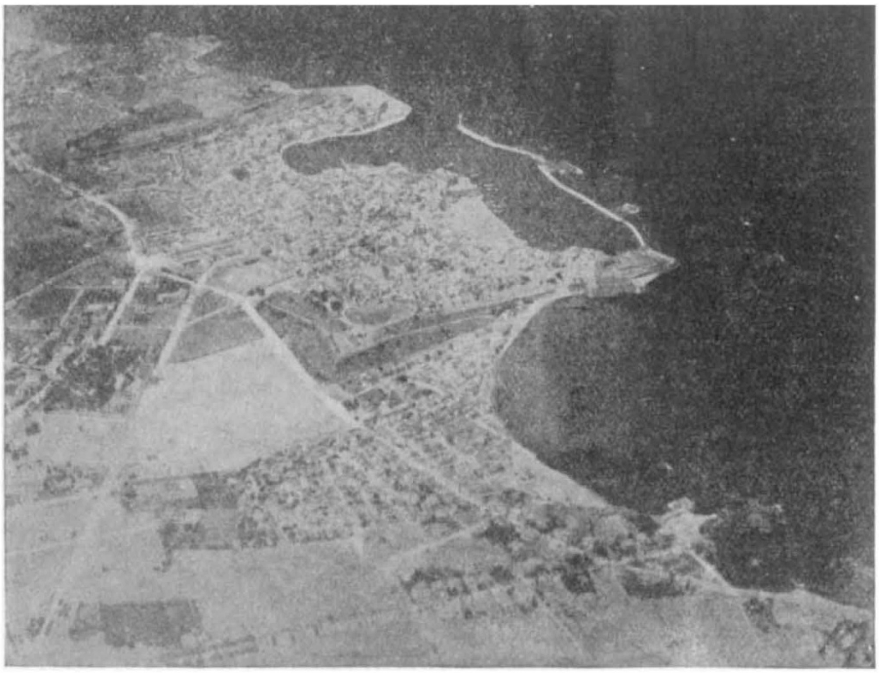

FIG. 2.—Canea from the east. From the *Geographical Journal*.

Routes from Egypt to Cape Town, and from England to St. John's (Newfoundland), Toronto, Winnipeg, and Vancouver are also suggested by Sir Frederick Sykes. The route from England to Egypt, although flown numerous times, presents difficulties, especially in Italy and the eastern Mediterranean. An alternative, but longer, route is tentatively suggested from Naples *via* Sicily, Malta, Tripoli, and the northern coast of Africa. The chief problem seems to be in the provision of a suitable aerodrome at Malta, for, once the African coast is reached, favourable conditions are found.

Helium: Its Discovery and Applications.

By DR. WILLIAM J. S. LOCKYER.

THE year 1868 is rendered memorable in the advancement of solar physics by the fact that the spectroscope was first used on an eclipsed sun. Up to that time the composition of the prominences and corona was unknown, although both these phenomena were then proved to be truly solar, the result of diligent systematic application of photography to eclipse problems since the year 1860.

On August 18, 1868, a total solar eclipse occurred in the Indian and Malayan peninsulas, lasting for about five minutes and thirty-eight seconds. This event afforded astronomers an opportunity of applying the spectroscope, in conjunction with the telescope, to determine what the prominences were really made of. On this occasion not only were all the expeditions successful, but an almost identical discovery was also made by the numerous observers.

It was observed that the prominences gave spectra of bright lines, and, with the means of recognition available at the few moments of totality, the red, green, and blue lines which were seen were attributed to the gas hydrogen, while the strong, bright yellow line was stated to be due to the luminous emission of sodium.

During this eclipse the distinguished French astronomer, Janssen, was so struck with the brilliancy of the prominence lines in his spectroscope that he considered it certain he would be able to see the bright lines without an eclipse at all. This he did during the following seventeen days which he spent at the eclipse station, observing the prominences on the limb of the sun.

The achievement of Janssen was based upon principles which in 1866 had been placed before the scientific world by Sir Norman Lockyer. Owing, however, to regrettable delays in the delivery of the instrument which was ordered in the beginning of the year 1867, and being specially made for him from funds supplied from the Government Grant Committee, Lockyer did not receive it until October 16, 1868. He first used it on October 20, observing the bright lines which had been recorded in the August eclipse.

Both Janssen and Lockyer communicated the results of their discoveries to the Paris Academy of Sciences, and these despatches arrived a few minutes of each other on the same day. In honour of the joint discovery the French Government struck a special medal (Fig. 1).

It is interesting as a matter of history to refer here to the first communication which Lockyer made to the Royal Society with reference to his first successful observation.

October 20, 1868.

SIR,—I beg to anticipate a more detailed communication by informing you that, after a number of failures, which made the attempt seem hopeless, I have this morning perfectly succeeded in obtaining and observing part of the spectrum of a solar prominence.

As a result I have established the existence of three bright lines in the following positions:—

(i) Absolutely coincident with C.
(ii) Nearly coincident with F.
(iii) Near D.

The third line (the one near D) is more refrangible than the more refrangible of the two darkest lines by eight or nine degrees of Kirchhoff's scale. I cannot speak with exactness, as this part of the spectrum requires re-mapping. . . .

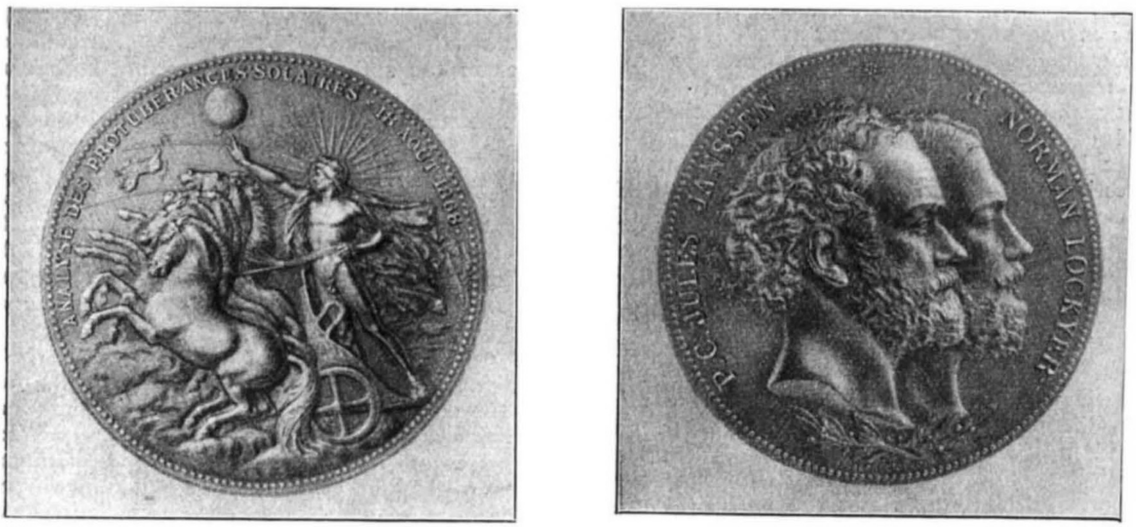

FIG. 1.—Medal struck by the French Government in honour of the joint discovery of the composition of the prominences by Janssen and Lockyer in the year 1868.

From the above it will be noticed that Lockyer gives the position of the bright yellow line as near D, and not coincident with D, D being the lines of emission of sodium previously referred to.

With regard to the behaviour of this line, he states in a later communication (November 19, 1868):—

There is a line in the yellow, most probably proceeding from the substance which gives off the light at C and F, as the length of this line, as far as the later observations with the more correctly adjusted instrument go, is the same as that of those in C and F.

This statement shows that the yellow line behaved like the lines of hydrogen, and the view put forward then was that probably this line might be due to hydrogen also. The line was called D_3 to differentiate it from the double line of sodium D_1 and D_2.

A considerable amount of work was now done with regard to D_3, for no substance was found in the laboratory which could produce this line.

By studying the behaviour of D_3 in relation to the hydrogen lines, throwing the image of the sun's limb on to the slit of a spectroscope, Lockyer found that the lines were distorted—*i.e.* there were changes of wave-length due to movements of the material in the sun. The orange line was, however, observed to behave quite differently from either of the hydrogen lines, showing that a different substance was in question.

Hence [as Lockyer remarks] we had to do with an element which we could not get in our laboratories, and therefore I took upon myself the responsibility of coining the word *helium*, in the first instance for laboratory use. At the time I gave the name I did not know whether the substance which gave us the D_3 was a metal like calcium or a gas like hydrogen, but I did know that it behaved like hydrogen, and that hydrogen, as Dumas had stated, behaved as a metal ("Sun's Place in Nature," p. 33).

In the following years numerous other lines in the sun and stars were found associated with the yellow line, but the origins of these were all *unknown* and designated as such.

It was not until the year 1895 that the terrestrial equivalent of this well-known yellow and other lines was discovered. "In the course of investigations on argon," so wrote Sir William Ramsay in a communication to the Royal Society (Proc. Roy. Soc., vol. lviii., p. 65) on March 26, 1895, "some clue was sought for which would lead to the selection of one out of almost innumerable compounds with which chemists are acquainted with which to attempt to induce argon to combine."

Acting on a suggestion by Sir Henry Miers, who directed attention to the work of Dr. Hillebrand in 1888 on the occurrence of nitrogen in uraninite, etc., Sir William Ramsay employed the mineral clèveite, essentially a uranate of lead containing rare earths. He treated this mineral, and from it extracted a small quantity of gas, which he subjected to spectroscopic examination. To use his own words, as printed in the above-mentioned communication :—

Several vacuum tubes were filled with this gas and the spectrum was examined, the spectrum of argon being thrown simultaneously into the spectroscope. It was at once evident that a new gas was present along with argon.

Fortunately, the argon tube was one which had been made to try whether magnesium poles would free the argon from all traces of nitrogen. This it did; but hydrogen was evolved from the magnesium, so that its spectrum was distinctly visible. Moreover, magnesium usually contains sodium, and the D line was also visible, though faintly, in the argon tube. The gas from clèveite also showed hydrogen lines dimly, probably through not having been filled with completely dried gas.

On comparing the two spectra, I noticed at once that while the hydrogen and argon lines in both tubes accurately coincided, a brilliant line in the yellow, in the clèveite gas, was nearly, *but not quite*, coincident with the sodium line D of the argon tube. Mr. Crookes was so kind as to measure the wave-length of this remarkably brilliant yellow line. It is 587·49 millionths of a millimetre, and is exactly coincident with the line D in the solar chromosphere, attributed to the solar element which has been named *helium*.

Thus was the terrestrial equivalent of the helium line discovered after an interval of twenty-seven years.

Solar observations had shown that this line was observed high in the chromosphere, indicating that the density of the gas should be very low. Special interest, therefore, attached to the determination of this important property. In a preliminary experiment Sir William Ramsay obtained 3·9 as a maximum number for the density of helium, oxygen being 16, thus showing that the surmise was correct. Soon after this discovery Lockyer prepared some of the gas from bröggerite, and established the fact that numerous lines, designated "unknown," in the spectra of the chromosphere, nebulæ, and stars, were due to this gas.

Thus from an observation of the sun a new terrestrial gas was discovered, and from this terrestrial gas the origins of a host of unknown lines in the spectra of the heavenly bodies were explained.

Like hydrogen, helium has a wide diffusion in space, for not only is it in strong evidence in the hot stars, but it also must occur in such cooler stars as Arcturus, since this star is at about the same temperature as our sun, in which we know helium is present. In our atmosphere helium is one of the rarer constituents, being present in the proportion of about one volume in 250,000.

Up to the last few years the amount of helium which has been collected has been small, owing to the costly process of obtaining it, but during the war a demand for it in large quantities arose because of its lightness and non-inflammable nature. Helium is the lightest gas known next to hydrogen, of which it has about 92 per cent. of the buoyancy or lifting power. It was intended to supply a fleet of airships with this gas, and great fractionating plants were laid down in the United States of America capable of separating helium from natural gas at a very moderate cost. It was due to the above-mentioned demand that helium became more widely known, and attention was at once paid to bring together all the information that had been published about it as an aid to that enterprise.

The U.S. Department of Commerce took the matter in hand, and under Dr. S. W. Stratton, the director of the Bureau of Standards, a bibliography of scientific literature relating to helium was compiled. The information (more than 400 references) thus brought together has since (September 10, 1919) been published in pamphlet form in a Circular of the Bureau of Standards (No. 81), and will be found a very valuable source of reference.

The importance of helium to-day may be briefly summarised from the following extract from the introduction to this circular :—

Helium has probably been the most interesting of all the elements to the theoretical scientist on account of the romantic history of its discovery, its occurrence in a remarkable condition of solid solution in many minerals, its formation as a product of the disintegration of the radio-active elements, its liquefaction after a decade of unsuccessful attempts by some of the world's greatest experimenters, the attainment by its use of temperatures below those at which the resistances of pure metals vanish, its many unique physical properties, and the many important theoretical conclusions which have been drawn from its behaviour.

All of these points of interest have been the subjects of very thorough investigation. The important developments of the future will probably be along the line of the applications of helium, many of which have already been suggested.

New Conceptions of Psychology.

THE results of Dr. Henry Head's clinical investigations[1] are exceptionally interesting from the philosophical point of view, for they are utterly incompatible with the older ideas of the introspective psychologists. In fact, his work is "a complete scientific refutation of all psychological theories which build up knowledge out of original sense-material" (NATURE, November 6, 1919, p. 267). Dr. Head has demolished the old psychology and created a new conception, in accordance with which "sensations depend neither for their existence nor for their psychical quality on the cerebral cortex, which has a purely interpretative function in regard to them."

The function of the cerebral cortex in sensation is to endow it with spatial relationships, with the power of responding in a graduated manner to stimuli of different intensities, and with those qualities by which we recognise the similarity or difference of objects brought into contact with the body. The old psychologists held that there was something in the external universe corresponding to primary sensations, which they regarded as being combined into the elements of perception. In accordance with such views the changes at the periphery were simple and became more complex the nearer they approached the highest centres in the brain. By submitting himself to a surgical operation in 1905 Dr. Head was able to demonstrate the complexity of the peripheral changes and the diffuseness of the impressions received. Moreover, by his clinical studies—monuments of patient research and marvellous insight—he has shown how these multitudes of diffuse peripheral changes gradually become integrated and rendered more specific in quality, space, and time as they approach the highest physiological levels in the central nervous system. The recognition of these facts gives an indication of the mode by which evolution has brought into existence such a nervous system as that of man. Lower, more impulsive, and less specific reactions become dominated by those that admit of choice. This conception turns orthodox psychology upside down.

Man's conceptions of space, time, and material rest ultimately on the nature of the spatial and temporal elements in sensation. These in turn are founded on complex physiological activities, many of which may never disturb consciousness directly; although they do not enter into the province of introspective psychology, they are responsible for much that is usually attributed to the action of the mind. Dr. Head's work on the cerebral cortex represents the culmination of an intensive investigation of the sensory system upon which he has been engaged for more than a quarter of a century. In 1893 he was studying the phenomena of the localisation of the pain associated with visceral disturbances and incidentally mapping out the distribution of the sensory nerves. Then he began the analysis of the components of the sensory nerves; and to test the problems that called for solution he invited Mr. James Sherren to cut one of the main sensory nerves of his (Head's) arm, and with the help of Dr. Rivers he studied the process of the restoration of function in the severed nerve. By this means he was able to differentiate between the three kinds of sensory nerves distributed to his arm:—

(*a*) The deep afferent system supplying the connective-tissues, muscles, joints, and tendons, in virtue of which is conferred the power of recognising movement and appreciating the position of any part of the limb, as well as of localising pressure and responding to certain aspects of pain;

(*b*) A punctate afferent mechanism in the skin, which Dr. Head has called "protopathic," the primitive nature of which is shown by the early restoration to activity (a little more than six weeks in Dr. Head's arm) of its end-organs after the nerve has been reunited, by the specifc nature of the response of each set of end-organs, and by the diffuse "all-or-nothing" nature of the response, *i.e.* the absence of any graduation corresponding to the intensity of the stimulus; and

(*c*) Superimposed over this older mechanism another cutaneous system of later development and higher functions, which Dr. Head calls "epicritic." Epicritic sensibility is not restored for many months after the reappearance of protopathic sensibility, the diffuse reaction of which is then checked and controlled; and the effects of stimulation are modulated according to the intensity and locality of the exciting agent. It is concerned with the finer degrees of tactile and thermal discrimination and is opposed to, and controls, the diffuse "all-or-nothing" reaction of protopathic sensibility.

It has long been known that the sensory paths in the central nervous system had a twofold terminus, represented by the thalamus and the cerebral cortex. It remained for Dr. Head to interpret the meaning of this arrangement. He

[1] "Sensation and the Cerebral Cortex," *Brain*, vol. xli., part ii., 1918.