erect suitable buildings for the Science Museum of the Department of Science and Art, and for the extension of its Science Schools, in accordance with the recommendations of the Royal Commission over which the Duke of Devonshire presided in 1874, as well as of various Committees and other high scientific authorities, and of a Treasury Committee appointed in 1889.

II. And whereas when in 1891 the Government had proposed to erect an Art Gallery on the site, a Memorial, signed by the President and Officers of the Royal Society and representatives of the Universities of Oxford, Cambridge, and of many other learned bodies both in London and in the provinces, was addressed to the Most Honourable the Marquis of Salisbury, K.G., F.R.S., Premier and Secretary of State for Foreign Affairs, showing cause why the site should not thus be allocated.

III. And whereas the scheme was withdrawn, and it was stated by the late Right Honourable W. H. Smith, M.P., that "additions to the College of Science must, in any case, take the form of a separate building divided from the present building by Exhibition Road," and since then plans have been prepared on information supplied on the instructions of Her Majesty's Treasury by the professors concerned.

IV. And whereas this arrangement has been generally accepted since 1876, when the Royal Commission for the Exhibition of 1851 offered land and a building with a view of carrying out the recommendations of the Duke of Devonshire's Commission to provide the needed accommodation for Science at South Kensington.

V. And whereas it was expected that this arrangement would be carried out, when in 1890 the Government acquired the land on the West side of Exhibition Road, which was sold by the Royal Commission of the Exhibition of 1851 at one-third its market value, on the condition that buildings for Science and the Arts should be erected on it.

VI. And whereas we are informed that this arrangement is in danger of being altered by the erection of Science buildings on the East side of Exhibition Road.

We, the undersigned Fellows of the Royal Society, desire most respectfully to express to your Lordship our strong opinion that it is desirable to adhere to the policy, namely, that the needful expansion of the Science Buildings at South Kensington should be provided for on the West side of Exhibition Road, which has been acted upon and publicly acknowledged by the Government since 1890, and is in strict harmony with the recommendation of the Duke of Devonshire's Commission. We are confirmed in this opinion by the fact that the space which we understand is available for Science on the East side of Exhibition Road is but a small fraction of that which is devoted to similar purposes in many foreign towns.

(Signed)

LISTER, President of the Royal Society.
JOHN EVANS, Treasurer of the Royal Society.
M. FOSTER, Secretary of the Royal Society, Professor of Physiology, Cambridge.
ARTHUR W. RUCKER, Secretary of the Royal Society.
E. FRANKLAND, Foreign Secretary of the Royal Society.
JOS. D. HOOKER, Past President of the Royal Society.
G. G. STOKES, Past President of the Royal Society.
KELVIN, Past President of the Royal Society.
WILLIAM CROOKES, Past President, Chemical Society and Institution of Electrical Engineers.
T. CLIFFORD ALLBUTT, Regius Professor of Physic, Cambridge.
G. CAREY FOSTER, Professor of Physics, University College, London.
A. W. REINOLD, Professor of Physics, Royal Naval College, Greenwich.
WILLIAM RAMSAY, Professor of Chemistry, University College, London.
JAMES DEWAR, Professor of Chemistry, Royal Institution.
OSBERT SALVIN.
LUDWIG MOND, Past President of the Society of Chemical Industry.
W. H. M. CHRISTIE, Astronomer Royal.
W. H. WHITE, Vice-President, Institute of Naval Architects.
BENJAMIN BAKER, Past President, Institution of Civil Engineers.
W. H. PREECE, Engineer in Chief, G.P.O.
RICHARD TEMPLE.
W. CAWTHORNE UNWIN, Professor of Engineering, Central Technical College.
R. H. INGLIS PALGRAVE.
W. M. HICKS, Principal, University College, Sheffield.
JOHN KIRK, G.C.M.G., K.C.B.
RICHARD STRACHEY, Chairman, Meteorological Council.
C. W. WILSON, Major-General R.E.
FRANCIS ELGAR, Vice-President, Institute of Naval Architects.
E. RAY LANKESTER, Linacre Professor, Oxford.
RICHARD T. THORNE.
A. B. KEMPE, Past President, Mathematical Society.
SHELFORD BIDWELL, President, Physical Society.
SILVANUS P. THOMPSON, Principal and Professor of Physics, Technical College, Finsbury.
ROSSE.
P. L. SCLATER.
JOHN PERRY.
G. M. MINCHIN.
SIDNEY MARTIN, M.D., Professor of Pathology, University College, London.
G. D. LIVEING, Professor of Chemistry, Cambridge.
HENRY E. ARMSTRONG, Professor of Chemistry, Central Technical College.
R. MELDOLA, Professor of Chemistry, Technical College, Finsbury.
P. H. PYE-SMITH, M D.
A. A. COMMON, Past President, Royal Astronomical Society.
RAYLEIGH.
J. BURDON-SANDERSON, Regius Professor of Medicine, Oxford.
W. GRYLLS ADAMS, Professor of Natural Philosophy and Astronomy, King's College, London.
H. CHARLTON BASTIAN, M.D.
J. G. BAKER.
J. WOLFE BARRY, Past President, Institution of Civil Engineers.
G. JOHNSTONE STONEY, Vice-President, Royal Dublin Society.
HENRY E. ROSCOE, Past President, Chemical Society.
WYNDHAM R. DUNSTAN.
J. H. GLADSTONE, Past President, Chemical Society.
F. D. GODMAN, Past President, Entomological Society.
J. VIRIAMU JONES, Professor of Physics, University College, Cardiff.
EDWARD B. POULTON, Hope Professor of Zoology, Oxford.
FREDERICK J. JERVIS-SMITH, University Lecturer in Mechanics, Oxford.
J. NORMAN LOCKYER, Member of the Royal Commission for the Exhibition of 1851.
W. J. L. WHARTON, Hydrographer to the Admiralty.
W. PALMER WYNNE, Hon. Secretary, Chemical Society.
J. W. SWAN, President, Institution of Electrical Engineers.
C. V. BOYS, Vice-President of the Physical Society.

LIQUID HYDROGEN.

A VERY remarkable achievement, which will redound to the credit of English science, has been performed within the walls of the Royal Institution. For some time past it has been a matter of general knowledge that Prof. Dewar has been preparing for an attempt to produce liquid hydrogen on a large scale. Money has been freely subscribed for investigations to be carried on at low temperatures, and the laboratories of the Royal Institution have gradually approached more and more nearly to the likeness of an engineering workshop. Very grave difficulties had to be encountered, and success seemed long in coming; but on Tuesday, May 10, Prof. Dewar was able to inform the President of the Royal Society that on that day both hydrogen and helium had succumbed to his attack.

All this is typical of British methods. The members of a great private Institution have secured the services of a man in whose abilities they believe. They supply him freely with the sinews of war, and he justifies their confidence by achieving a success which, as far as our present knowledge goes, could only have been won by a combination of great resources and very great skill. We heartily congratulate Prof. Dewar and his supporters on this result, and on the fact that the world now possesses liquid hydrogen—so to speak—on tap.

The conditions of the experiment give some idea of the difficulties which have been overcome. Hydrogen cooled to – 205° C. escaped, under a pressure of 180 atmospheres, into a vacuum vessel surrounded by a space which was itself maintained at a temperature of – 200° C. Thus constrained it liquefied.

About 20 c.c. of the liquid were collected in another protected vessel, into which it dripped from that above described. It is transparent, colourless, with a well-defined meniscus, and apparently with a relatively high refractive index.

We sincerely hope that this great success will not be marred by a controversy as to priority, of which some symptoms have already appeared in a leading article in the *Standard* and elsewhere. The time is long past in which the liquefaction of a gas was interesting as proving that under proper conditions all substances can be liquefied. For many years nobody has had doubts on that point. We have learned to look upon the liquefaction of a gas as important, mainly because it affords a means of studying at very low temperatures not only the liquefied gas itself, but also other kinds of matter. Experiments in which momentary liquefaction is attained are chiefly interesting as showing that some approach is made to realising the condition under which more stable results may be expected. They take a much higher rank if the skilful experimenter can wrest from the substance in a transitory condition some information as to the properties which the material would have if it were reduced to the state which has been called a "static liquid." To attain these results in the case of so intractable a substance as hydrogen is an achievement of a very high order. But when this has been done it cannot be fairly contended that all the rest follows as a matter of course.

There have been discoveries in which the first step was all-important. The discovery, for instance, of the Röntgen rays opened an entirely new range of facts to scientific investigation. In other cases the root-idea had long been common property, and the merit, like that of Captain Bunsby's observation, "lays in the application of it." It has long been known that if hydrogen were ever liquefied in quantity, both cooling to a very low temperature, and a rapid expansion would play a large part in the operation. The difficulties of the experiment lay, not in understanding these principles, but in applying them, and the difficulties were so enormous that the investigator who has overcome them deserves our admiration. He has performed not only a great "tour de force," but has cleared the way to a region hitherto unexplored, to a whole series of researches which become more interesting and important as the absolute zero is more nearly approached.

It appears to us, therefore, that there is no necessity to belittle the work either of Prof. Dewar or of others who have been active in the same line of research. Cailletet and Wroblewski obtained results which, to judge from his address to the French Academy, reported in the *Times* of May 17, are regarded as inconclusive by so high an authority as M. Moissan. At the best, and assuming the liquid obtained to have been hydrogen, its existence in the liquid form was very brief. Prof. Olszewski also has published a full account of how he obtained hydrogen for a moment in a mist-like state, in which he measured some of the constants of the liquid. Yet nothing but the paucity of language could lead to the idea that this feat was the same as that which Prof. Dewar has accomplished. Had we no other evidence of the existence of water, something might be learned from the study of clouds; but nobody contends, on that ground, that a cloud is the same thing as a duck-pond. Yet the difference between the two is hardly, if at all, greater than the practical difference between hydrogen without visible form or surface, in a state of momentary or "dynamical" liquefaction, and hydrogen as a "static" liquid, with a clearly defined meniscus, boiling away quietly under conditions which enable the observer to record its appearance, to handle and to use it.

By insisting on this difference, we do not for a moment wish to question the merits of Prof. Olszewski's work. He used the means at his disposal admirably, and made measurements of the critical temperature and boiling-point of hydrogen, which, tested as they were by check experiments on oxygen and ethylene, were of great value.

Prof. Olszewski was, however, fully conscious of the difference between these results and those which Prof. Dewar has now achieved. He again and again explained with the utmost candour that he had seen no meniscus, and that he had failed to reduce hydrogen to the state of a "static liquid." He further expressed the opinion that these desiderata would not be attained until a cooling agent was discovered in the form of a gas, with a density between those of hydrogen and nitrogen. No such gas has been used by Prof. Dewar, yet hydrogen has now been seen by himself, by Lord Rayleigh and others as a well-defined liquid mass. The merits of this achievement will be in no wise diminished by a generous recognition of the researches of Olszewski, but on the other hand it would be most unfair to minimise the magnitude of Prof. Dewar's success by classing it merely as a repetition, on a larger scale, of another man's work. It is in the words of M. Moissan a "wonder of modern chemistry."

The following abstract of the paper will give further details:—

In a paper entitled "The Liquefaction of Air and Research at Low Temperatures," read before the Chemical Society, and published in the *Proceedings*, No. 158, an account is given of the history of the hydrogen problem and the result of my own experiments up to the end of the year 1895. The subject is again discussed in a Friday evening lecture on "New Researches on Liquid Air" (*Roy. Inst. Proc.*, 1896), which contains a drawing of the apparatus employed for the production of a jet of hydrogen containing liquid. It was shown that such a jet could be used to cool bodies below the temperature that could be reached by the use of liquid air, but all attempts to collect the liquid in vacuum vessels failed. No other investigator has so far improved on the results described in 1895. The type of apparatus used in these experiments worked well, so it was resolved to construct a much larger liquid air plant, and to combine with it circuits and arrangements for the liquefaction of hydrogen, which will be described in a subsequent paper. This apparatus, admirably constructed by the engineers, Messrs. Lennox, Reynolds, and Fyfe, took a year to build up, and many months have been occupied in testing and making preliminary trials. The many failures and defeats need not be detailed.

On May 10, starting with hydrogen cooled to – 205° C., and under a pressure of 180 atmospheres, escaping continuously from the nozzle of a coil of pipe at the rate of about 10 cubic feet to 15 cubic feet per minute, in a vacuum vessel double silvered and of special construction, all surrounded with a space kept below – 200° C. Liquid hydrogen commenced to drop from this vacuum vessel into another doubly isolated by being surrounded with a third vacuum vessel. In about five minutes, 20 c.c. of liquid hydrogen were collected, when the hydrogen jet froze up from the solidification of air in the pipes. The yield of liquid was about 1 per cent. of the gas. The hydrogen in the liquid condition is clear and colourless, showing no absorption spectrum, and the meniscus is as well defined as in the case of liquid air. The liquid must have a relatively high refractive index and

dispersion, and the density must also be in excess of the theoretical density, viz. 0·18 to 0·12, which we deduce respectively from the atomic volume of organic compounds, and the limiting density found by Amagat for hydrogen gas under infinite compression. My old experiments on the density of hydrogen in palladium gave a value for the combined body of 0·62, and it will be interesting to find the real density of the liquid substance at its boiling-point. Not having arrangements at hand to determine the boiling-point, two experiments were made to prove the excessively low temperature of the boiling fluid. In the first place, if a long piece of glass tubing, sealed at one end and open to the air at the other, is cooled by immersing the closed end in the liquid hydrogen, the tube immediately fills, where it is cooled, with solid air. The second experiment was made with a tube containing helium.

The *Cracow Academy Bulletin* for 1896 contains a paper by Prof. Olszewski, entitled "A Research on the Liquefaction of Helium," in which he states "as far as my experiments go, helium remains a permanent gas, and apparently is much more difficult to liquefy than hydrogen." In a paper of my own in the *Proceedings* of the Chemical Society, No. 183 (1896-97), in which the separation of helium from bath gas was effected by a liquefaction method, the suggestion was made that the volatility of hydrogen and helium would probably be found close together, just like those of fluorine and oxygen. Having a specimen of helium which had been extracted from bath gas, sealed up in a bulb with a narrow tube attached, the latter was placed in liquid hydrogen, when a distinct liquid was seen to condense. From this result it would appear that there cannot be any great difference in the boiling points of helium and hydrogen.

All known gases have now been condensed into liquids which can be manipulated at their boiling points under atmospheric pressure in suitably arranged vacuum vessels. With hydrogen as a cooling agent, we shall get within 20° or 30° of the zero of absolute temperature, and its use will open up an entirely new field of scientific inquiry. Even as great a man as James Clerk Maxwell had doubts as to the possibility of ever liquefying hydrogen (see "Scientific Papers," vol. ii. p. 412). No one can predict the properties of matter near the zero of temperature. Faraday liquefied chlorine in the year 1823. Sixty years afterwards Wroblewski and Olszewski produced liquid air, and now, after a fifteen years' interval, the remaining gases, hydrogen and helium, appear as static liquids. Considering the step from the liquefaction of air to that of hydrogen is relatively as great in the thermo-dynamic sense as that from liquid chlorine to liquid air, the fact that the former result has been achieved in one-fourth the time needed to accomplish the latter, proves the greatly accelerated race of scientific progress in our time.

The efficient cultivation of this field of research depends upon combination and assistance of an exceptional kind; but in the first instance money must be available, and the members of the Royal Institution deserve my especial gratitude for their handsome donations to the conduct of this research. Unfortunately its prosecution will demand a further large expenditure.

During the whole course of the low temperature work carried out at the Royal Institution, the invaluable aid of Mr. Robert Lennox has been at my disposal; and it is not too much to say that but for his engineering skill, manipulative ability, and loyal perseverance, the present successful issue might have been indefinitely delayed. My thanks are also due to Mr. J. W. Heath for valuable assistance in the conduct of these experiments.

NOTES.

M. MARCELLIN BOULE, of Paris; Dr. W. H. Dall, of Washington (D.C.), U.S.A.; and M. A. Karpinsky, of St. Petersburg, have been elected Foreign Correspondents of the Geological Society.

PROF. MICHAEL FOSTER has been elected President of the British Association for the meeting to be held at Dover next year.

THE annual conversazione of the Society of Arts will take place at the Natural History Museum, Cromwell Road, S.W., on Wednesday, June 22. The reception will commence at 9 p.m.

A CONVERSAZIONE of the Metropolitan Counties Branch of the British Medical Association will be held in the Museum of the Royal College of Surgeons on Tuesday, June 7.

THE Prince of Wales and the Duke of York were present on Monday night at a special meeting of the Royal Geographical Society, held in commemoration of the 400th anniversary of the discovery of the Cape route to India by Vasco da Gama. The president, Sir Clements Markham, was in the chair, and the address delivered by him upon the occasion is published in another part of this issue. At Lisbon the Vasco da Gama celebrations were inaugurated on Tuesday by the firing of a salute of 101 guns by the forts and the ships anchored in the Tagus. At a meeting of the Lisbon Geographical Society, Baron von Kell, the Dutch Minister to Portugal, presented to King Charles an album and a gold wreath, as the homage of Holland to Vasco da Gama. His Majesty accepted the gift, and said that Portugal was grateful for this act of homage.

THE Judicial Committee of the Privy Council recently granted the Hon. C. A. Parsons an extension of five years for his patent, dated April 23, 1884, for "improvements in rotary motors actuated by elastic fluid pressure and applicable also as pumps." The reasons for this decision were stated on Saturday to be that Mr. Parsons had not yet been adequately remunerated for his invention.

DR. D. J. LEECH, Professor of Materia Medica and Therapeutics in the Victoria University; Prof. W. Ramsay, of University College, London; and Prof. Ira Remsen, the Professor of Chemistry at the Johns Hopkins University, Baltimore, have been elected honorary members of the Pharmaceutical Society of Great Britain.

IN the High Court of Justice on Saturday an application was made on behalf of the shareholders of the Sheffield Botanical and Horticultural Society, that the trustees might be ordered to sell its property in pursuance of resolutions passed at meetings of the members, and distribute the proceeds of the sale among the members. It was urged by the Attorney-General that the property of the Society ought not to be so divided, but ought to be given to some other institution of a like character. The judgment was, however, that the applicants were entitled to the order they asked for.

PROF. J. M. SCHAEBERLE has resigned his post as astronomer at the Lick Observatory, California.

MR. HENRY WILDE, F.R.S., has been elected an honorary member of the Institution of Electrical Engineers.

THE Boston Society of Natural History has awarded the Grand Honorary Walker Prize of one thousand dollars to Mr. Samuel Hubbard Scudder, of Cambridge, Mass., for his contributions to entomology. The prize is awarded every five years, and the four previous recipients have been Mr. Alexander Agassiz, Prof. Joseph Leidy, Prof. James Hall, and Prof. James D. Dana.

THE annual electrical exhibition was opened at New York City on May 2. The President of the United States, following the usual custom, set the machinery in motion by pressing a button at Washington. He also sent congratulatory messages, as did the Vice-President. The opening address was by Chauncey Depew, who supplemented his remarks by firing off a dynamite gun, without wires by the long-distance system of telegraphy, and by blowing up a mimic steamer in the tank by a submarine-mine.

WE regret to record the death of Mr. W. C. Lucy, F.G.S., formerly of Brookthorpe, near Gloucester. For upwards of forty years Mr. Lucy was one of the most active and enthusiastic members of the Cotteswold Naturalists' Field Club. To the *Proceedings* of the Club he contributed numerous papers, including observations on the Drifts of the Severn, Avon and