structure is still a matter of pure conjecture. It is to be hoped that the authors will investigate this aspect of the research, difficult though it will probably prove to be.

The authors entitled their paper "A Note on the Microstructure of Commercially Pure Iron between Ar3 and Ar2." Strictly speaking, this is not the case. Mr. P. Tucker, who took cooling and heating curves for them, found Ac3 at 888° C. and Ar3 at 874° C., and makes the significant statement that it was "practically impossible so far to determine the Ar2 point of this material even on the most delicate instruments." Now the new structural constituent is shown in the photographs at 899° C., *while the material was still in the γ range*—above Ar3. It does not appear, therefore, that the upper limit of brittleness coincides with the Ar3 change. Ar2 is normally found at about 765° C. in commercially pure irons. This is about 35° lower than the temperature at which the eutectoid structure disappeared. No iron has ever been found to give Ar2 at so high a temperature as 800° C., which is actually below that at which the new constituent vanishes. Neither, therefore, does the lower limit of brittleness coincide with the Ar2 change, assuming that it does exist, according to the evidence at present available.

H. C. H. CARPENTER.

RECENT RESEARCHES AT VESUVIUS.

PROF. ALESSANDRO MALLADRA, the successor of Mercalli at the Royal Vesuvian observatory, has published a number of papers, from 1912 onwards, on the volcanic manifestations and progressive changes in the great crater formed in 1906. It has been possible in recent years to descend, by hazardous paths, to the edge of the central funnel, 250 metres below the crater-edge, and valuable observations have been made on the gases emitted from the fumaroles. Prof. Malladra furnishes a well-illustrated summary of the conditions in 1914 in "Nel cratere del Vesuvio" (*Boll. reale Soc. Geografica*, 1914, p. 753). The gradual widening of the crater by the falling in of its cliffs is shown in plan in a paper, "Sulle modificazioni del Vesuvio dopo il 1906" (*ibid.*, p. 1237). The small aperture of 1900 is also here indicated, almost immediately over the pit that is now active. The volcano remained quiet, in a solfataric stage, for seven years after the enormous outburst of 1906; but a glowing funnel opened in the floor of the crater of explosion on July 5, 1913. Prof. Malladra was engaged in a hypsometrical survey on the cone a few hours after this outbreak ("Sui fenomeni consecutivi all' apertura della bocca 5 Luglio, 1913," *Rend. R. Accad. Sci. Fis. e Mat. di Napoli*, fasc. 11 and 12, 1914), and has recorded a true incandescence, accompanied by the emission of fresh scoriæ, specimens of which were collected on one of many later visits. The "yellow fumarole" in the crater gave a temperature-reading of 128° C. in 1911. In September, 1913, this had risen to 330°, and in October to 347°. During the collection of gases from this fumarole for analysis, water condensed, containing hydrochloric acid in the proportion of 9·21 grams per 100 c.c., and smelling strongly of sulphuretted hydrogen. The author points out that, following the arguments of Brun as to the possibility of the permeation of water into a heated mass from without, this water must be truly magmatic. He thus provides further evidence, in addition to that of Day and Shepherd, against Brun's main contention.

Prof. Malladra illustrates ("I Gas vulcanici e la Vegetazione," *Boll. Soc. Sismologica Ital.*, vol. xviii.) the acid gases of Vesuvius rolling in a dense cloud down the mountain slope. They deposit on the leaves and branches of the trees a white dust consisting of chlorides and sulphates of iron and the alkalies; and these anhydrous or slightly hydrated gases are easily recognisable to the experienced eye from the ordinary masses of water vapour. Like the descending clouds that brought death to Saint-Pierre and Morne Rouge, they consist of very finely divided solid matter and gas, and resemble the smoke of a conflagration. The caustic effect produces brown spots and decay in leaves, and experiments are in progress in the planting of bare parts of the Vesuvian slopes with Euonymus and with a bamboo, appropriately known as *Arundo Plinii*, which flourishes fairly upon Stromboli. Both these, it is hoped, will resist the acid emanations.

An investigation of the rainfall on Vesuvius, and of the distribution of snow on the variously heated areas near the vent ("La pioggia sul Vesuvio, 1863–1913," *ibid.*, vol. xviii.), contains an interesting passage on the snow-accumulations formed by the freezing of the vapour of the fumaroles. G. A. J. C.

FUEL RESEARCH.[1]

IN its first report[2] the Board stated that it had in view two main lines of research: first, a survey and classification of the coal seams in the various mining districts by means of chemical and physical tests in the laboratory, and, secondly, an investigation of the practical problems which must be solved if any large proportion of the raw coal at present burned in its natural state is to be replaced by the various forms of fuel obtainable from coal by carbonisation and gasification processes.

When the previous report was written it was believed that the survey and classification of coal seams might be proceeded with in advance of the second line of inquiry; but further consideration has shown that from the practical point of view the two lines are so thoroughly interdependent that they can be most satisfactorily dealt with side by side. This view will be further developed after the position and prospects with regard to the second line of inquiry have been more fully explained.

In preparation for the organisation of the first line, however, an experimental study of standard methods for the examination of samples of coal in the laboratory has been made. Hitherto in the systematic examination of coals in the laboratory there has been no generally accepted low-temperature carbonisation test. In the survey and classification of coals for the purposes of the present inquiries a test of this kind is practically indispensable. Certain existing tests are designed to ascertain the suitability of coal for gas- or coke-making, but as both these methods of carbonisation are carried out at temperatures above 900° C. they give little or no direct information as to the behaviour of the coal when carbonised at 500° to 600° C.

As a result of experimental work carried out for the Board in the fuel laboratory of the Imperial College of Science and Technology, a test has now been elaborated which by direct weighing and measurement gives the yields of gas, oil, water, and carbonaceous residue which result from carbonisation at any definite temperature. The apparatus is simple and is so arranged that the progress of the distillation can be watched from start to finish. The products can be weighed or measured with reasonable accuracy, and any or all of them can, if desired, be submitted to further examination.

[1] Report (slightly abridged) of the Fuel Research Board on its Scheme of Research and on the Establishment of a Fuel Research Station. (Published for the Department of Scientific and Industrial Research by H.M Stationery Office.) Price 2*d.* net.

[2] This report was not published.

With regard to the organisation which will ultimately be required in the principal coal-mining districts for the collection and registration of samples, the Board is glad to say that it has found every disposition on the part of the representatives of the coal-owners to co-operate in this work. It is not proposed to start any extensive organisation for this purpose until the preparations for the second line of inquiry are further advanced. The accumulation of large numbers of samples would serve no useful purpose at present, and would be decidedly inconvenient. It is certain that as soon as the arrangements for the examination and testing of samples are in working order it will be an easy matter to maintain the necessary supply of samples to keep the laboratories and the research station fully occupied.

In the first report the following statement with regard to the second line of inquiry was made:—

"The second of the proposed lines of inquiry has been led up to by a variety of influences during the past eight or ten years. Among these influences have been the demands for cheaper and more ample supplies of electrical energy, for home supplies of fuel oil for the Navy, of motor spirit for the Transport and Air Services, and last, though by no means least, for smokeless domestic fuel. This last has been brought about through the growth of public and municipal opinion on the subject of smoke prevention in cities and in industrial centres.

"The only development which would satisfy all these needs simultaneously would be the replacement of a large proportion of the raw coal which is at present burned in boilers, furnaces, and domestic fires, by manufactured fuels prepared from raw coal by submitting it to distillation.

"The greater part of the coal which is consumed in Great Britain is burned in its natural state as it comes from the mines. The question of the moment then is: To what extent can and ought the present use of raw coal to be replaced by the use of one or other of the various forms of fuel manufactured from coal—coke, briquettes, tar, oil, or gas? While there is already in the possession of experts a certain amount of knowledge and experience which might enable them to organise and direct schemes for the replacement of raw coal by manufactured fuel in particular directions and on a fairly large scale, no really comprehensive scheme can be formulated until certain perfectly definite problems in coal distillation have been solved.

"These problems can be solved only by carefully organised experiments on a working scale carried out under the conditions likely to arise in practice."

The gas retort and the coke oven have become highly developed appliances for the carbonisation of coal at temperatures ranging from 900° to 1200° C. In the former the primary object of the carbonisation is to obtain the maximum yield of *gas* suitable for domestic and industrial lighting and heating, while in the latter *coke* is regarded as the principal product. In both cases the by-products of the operation are of economic value, but are necessarily of secondary importance. In considering the broad question of the replacement of any considerable proportion of the coal which is at present being burned in its raw or natural state by manufactured forms of fuel, the part which may be played by high-temperature methods of carbonisation will need to be taken into account. For this purpose a great amount of experience is available, and trustworthy data on which to base the calculation of the economic possibilities are in existence.

The distillation of oil shales at low temperatures for the production of mineral oils, paraffin wax, and ammonia is a highly developed industry, but the oil shales are totally unlike coal in their nature and in the products which they yield, so that the experience gained in this industry, though undoubtedly valuable, is only indirectly useful so far as coal is concerned.

As regards the carbonisation of coal at low temperatures, there is no corresponding body of experience in existence, and there are very few properly accredited data available. Some work has been done by individual inventors and syndicates, and a certain amount of experience has been gained. While only portions of this experience have been disclosed, enough is known to justify the conclusion that much still remains to be done in devising the special forms of apparatus required for the economical carrying out of this type of carbonisation.

The way is clearly open for a serious attempt to determine whether an economical and efficient apparatus can be devised for the carbonisation of coal at low temperatures, and whether, by the use of such an apparatus, for the carbonisation of properly selected coals, products will be obtained of a collective value greater than that of the original coal *plus* the cost of carbonisation and handling. Obviously the evolution of an economical and efficient apparatus is at the root of the whole matter, for only after a thoroughly practical apparatus is available can trustworthy tests of the various classes of coal be made and the economic possibilities of the method be fully weighed and considered.

The solution of these fundamental problems will supply a new base from which to attack questions like the following:—

(1) Can the thirty-five to forty million tons of raw coal which is used every year for domestic heating be wholly or partially replaced by smokeless fuel, solid and gaseous, prepared by the carbonisation of this coal?

(2) Can adequate supplies of fuel oil for the Navy be obtained by carbonisation of the coal which is at present used in its raw form for industrial and domestic purposes?

(3) Can supplies of town gas be obtained more economically and conveniently by methods of carbonisation and gasification other than those at present in use in gasworks?

(4) Can electric power be obtained more cheaply if the coal used for steam raising is first subjected to processes of carbonisation and gasification?

(5) Will the more scientific development of the preparation and use of fuel, which would be implied in the successful working out of the foregoing questions, enable the peat deposits of the United Kingdom to take a serious place as economic sources of fuel for industrial purposes?

(6) Can the use of gaseous fuel in industrial operations be forwarded by the development of more scientific methods of combustion in furnaces, muffles, and ovens used in metallurgical, ceramic, and chemical operations?

The answers to these questions will be obtained only by co-ordinated research carried out on the lines of a broad and well-considered scheme. The subjects to be dealt with are already attracting the attention of serious workers in the industries, and it is to be expected that solutions of some of the problems will be supplied by these workers. The Board sincerely hopes that this will be the case. It would regard it as a great misfortune if the establishment of a Government organisation for fuel research were to result in the discouragement or limitation in any way of the activities of outside workers or organisations. It ventures to hope rather that many of these workers will be disposed to welcome a national scheme of research, the aims of which are broad and yet definite, and in which the more specialised contributions from all sides will naturally take their place.

In considering new and extensive schemes of carbon-

isation it is necessary to bear in mind that outlets for all the products of carbonisation must be found. The gas, coke, and shale-oil industries are all of old standing, and each has had to develop outlets for its products by patient and continuous effort. No new carbonisation scheme can be justified economically if it can only live by poaching on the preserves of the existing industries. Even if an efficient method of low-temperature carbonisation is evolved, it will be valueless in the wider sense unless profitable outlets for all the important products can be developed. It is obvious that the Fuel Research Board, which is in official touch with the Admiralty, the Ministry of Munitions, the Board of Trade, and other public departments, is exceptionally placed for the furtherance of schemes which involve the finding of large outlets for products new and old. It is known, for instance, that the Admiralty attaches great importance to the development of supplies of fuel oil from home sources, so that it may be taken for granted that this requirement alone would absorb all the oil which could be produced by the carbonisation of tens of millions of tons of coal per annum. This fact alone gives an entirely new aspect to the extension of carbonisation in hitherto untried directions, but while it will undoubtedly help on the economic side of the problem, it in no way relieves the pressure on the technical side. In a way, moreover, it accentuates the problem now to be referred to, the profitable disposal of the coke or carbonaceous residue left when the volatile products are distilled from the coal. The percentage of coke obtained varies with the quality of the coal and the temperature at which it is carbonised, but it may be taken on the average that each ton of coal carbonised will give about 15 cwt. of coke. Thus to obtain one million tons of fuel oil for the Navy it would be necessary to carbonise twenty million tons of coal, and the coke produced would amount to fifteen million tons.

The disposal of this very large quantity of coke or char at a profitable price must be regarded as the vital question if low-temperature carbonisation is to be established on a sound economic basis. The research scheme must therefore include a very complete inquiry on three main lines:—

(1) The use and value of this coke for the direct firing of steam boilers.

(2) Its gasification in producers for the manufacture of low-grade fuel gas and the recovery of its nitrogen as ammonia.

(3) Its use for industrial and domestic heating either directly, as it comes from the retorts, or after its conversion into briquettes.

The second of these inquiries will involve the development of a special form of gas-producer and auxiliary plant if the best results are to be obtained from the coke. It will also involve the development of a system of boiler firing in which fuel gas of 130 B.T.U. can be burned at least as efficiently as coal, both as regards thermal efficiency and the effective evaporation per square foot of heating surface.

In all that concerns the preparation and use of special forms of fuel there are two distinct stages of development to be passed successfully. In the first stage apparatus and methods have to be evolved and tested until a practical standard of efficiency is reached. In the second stage the consumers of fuel must be induced to study the new apparatus and methods until they thoroughly understand and in the end adopt them. This second stage will be most readily passed if an expert staff trained at a fuel research station is available to undertake the education of those who desire to adopt the new methods and appliances.

The use of town gas as a fuel for industrial purposes has made great strides during the past few years, and a number of experts are to-day engaged on the design and adaptation of furnaces and apparatus for these purposes. The actual practice of gas-heating still lags a long way behind the ideals of economy and efficiency, and there is room for much useful experimental inquiry into principles and methods.

The use of the lower grades of fuel gas, though successfully carried out in certain directions, is very imperfectly understood in the majority of industries in which gas might be used for heating and power purposes. In this direction there is scope for much useful work, both in research and in the education of experts and consumers.

A single illustration may be given of the complicated inquiries which will have to be conducted before an answer can be given to what seems to be a simple question.

There is a very general belief among electrical experts that the future of British industry will be greatly affected by the cost at which power in bulk can be supplied in the form of electricity. It has been proposed, for instance, that large electrochemical works should be established in this country for the manufacture of products which in the past have been manufactured in parts of the world where cheap water-power is available. In this connection it has been suggested that the cost of producing power from coal in this country would be substantially reduced if instead of burning the coal directly under the steam boilers it were first subjected to carbonisation and gasification processes which, in addition to fuel gas, would yield valuable by-products. Plausible statements have been issued showing the enormous savings or profits which would accrue if schemes of this sort were adopted. Unfortunately, these estimates have generally been made on a very slender foundation of knowledge and experience. On the other hand, those who, by experience and practice, are best qualified to judge hesitate to prophesy as to what the economic result of a combined carbonisation and power generating scheme would be, but they agree that the interests at stake are so great that the question ought to be authoritatively answered once for all. But no answer can be accepted which is not founded on the complete working out of the scheme, no important step in the series of operations being omitted or slurred over. This series of operations will start from the mechanical preparation of the coal and its conversion into solid, liquid, and gaseous products by carbonisation. It will end with the delivery of a known weight of high-pressure steam under the conditions most favourable for power production by turbo-generators. In the proposed scheme of research it will be seen that the investigation of each of the steps involved in the above inquiry is provided for. Three, at least, of these steps involve pioneering work on an industrial scale, and the work may occupy a considerable time. The Board realises that it is possible that the net result of this particular inquiry may be to show that purely as a means of cheapening the cost of electric power, the use of carbonisation methods has not much to commend it, but that certain incidental advantages will justify its use in particular cases.

The Fuel Research Station.

The scheme of research which has been outlined in this report can be efficiently carried out only in a fuel research station designed and equipped for the purpose, in which operations on an industrial scale can be carried out under proper working conditions.

It is desirable that the station should be within easy reach of London, that there should be ample railway and other facilities for the transport of coal from all parts of the kingdom, that there should be ready means for

the disposal of the large quantities of coke, oil, and gas which would be produced in the regular course of experimental work, and that a supply of labour, skilled and unskilled, should be available. It was realised that these conditions could be fulfilled only by a site in the neighbourhood of a large gasworks, and some months ago the Director of Fuel Research approached Dr. Charles Carpenter on the subject. Dr. Carpenter is chairman of the South Metropolitan Gas Company, and he is a member of the Carbonisation Sub-Committee of the Coal Conservation Sub-Committee of the Reconstruction Committee, of which the Director is vice-chairman. Following this conference, Dr. Carpenter, on behalf of the board of the South Metropolitan Gas Company, made the following very generous offer to this Board:—(1) To lease to the Government at a peppercorn rent sufficient land at the East Greenwich gasworks for the erection of a research station; (2) to prepare drawings and specifications for this station on lines to be laid down by this Board, and to make contracts for its erection; (3) to give every facility for the transport of coal and other supplies to the station, and to take over at market prices the surplus products, gas, tar, liquor, and coke resulting from the operations at the station. After further conferences a suitable site was agreed upon. The proposed site is a strip of level ground about 250 ft. wide by 700 to 800 ft. long, situated on the main siding which connects the gasworks with the South-Eastern Railway and with access to an existing road.

The foregoing scheme of research is obviously not intended to cover the whole of the territory which is open for exploration to-day. Still less ought it to be regarded as setting any limits to the exploration of new territories in the future. The root idea of the scheme is that certain fundamental changes in the preparation and use of fuel which have been proposed are of such far-reaching importance that the solution of the technical and economic problems involved ought to take precedence of all other matters. This does not mean that other lines of research will be ignored, but only that the larger issues must be kept well to the front until definite solutions of those technical and economic problems can be given. Though no direct reference has been made to the preparation and use of fuels from oil shales, brown coals, and peat, it is obvious that experimental inquiries on these matters will naturally find a place in the developments of the present scheme.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The term has begun with a greatly depleted number of undergraduates. The entry of freshmen, which used to average nearly 1000, fell in 1914 to 550, in 1915 to 238, and last year to 150. The number for the present academical year is about 100. Some colleges have none. The American Rhodes scholars, who have hitherto helped to raise the numbers above the vanishing point, are now called up for military service. Among the men who are now coming into residence for the first time are some who, after service at the front, have been discharged on the ground of wounds or sickness.

On October 10 a memorial tablet was unveiled at Oxford, commemorating the life and work of Roger Bacon. The tablet has been fixed to the old wall of the city, dating from early in the thirteenth century, close to the site of the Grey Friars Church in the precincts of which Roger Bacon was buried. The church has long since disappeared, but the position of the burial ground, though not the exact spot of Bacon's grave, is known. After the celebration at Oxford in 1914 of the seven hundredth anniversary of Bacon's birth, it was thought fitting that in addition to the statue then erected in the University museum, a permanent and public memorial should be set up as near as possible to the site of the Franciscan friary in which Bacon passed so many years of his strenuous life. This has now been accomplished, and the prophecy uttered by the Elizabethan dramatist Greene, which was recalled by Prof. James Ward, of Cambridge, at the ceremony in 1914 (see NATURE, June 18, 1914, p. 406), has at length been virtually fulfilled. The Latin inscription on the tablet is as follows:—

ROGERUS BACON
Philosophus insignis Doctor Mirabilis
Qui methodo experimentali
Scientiae fines mirifice protulit
Post vitam longam strenuam indefessam
Prope hunc locum
Inter Franciscanos suos
In Christo obdormivit
A·S·MCCXCII.

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THE College of Physicians and Surgeons, the Medical School of Columbia University, has decided to admit women on an equal standing with men. This step has been taken after long consideration, and has been hastened by a great change in woman's position in Europe since the outbreak of the great war. For many years past a large number of women have worked in the laboratories of the Department of Health of New York, and have done admirably. The laboratories in the hospitals, also, frequently employ women, and with the repeated disappearance of men owing to the draft and enlistments in the Medical Reserve Corps, many places will be vacant which can only be filled by women. The opening of the Columbia Medical School to women has been made possible by a gift of 10,000*l.* from Mr. G. W. Brackenridge, of San Antonio, Texas.

THE Glasgow libraries have taken a step in the right direction in publishing a detailed catalogue of all the works on aeronautics to be found on their shelves. The list is not a long one, owing to the lack of books upon the new science, but it is fairly complete, the most notable omission being the works of Eiffel, or the excellent English translation thereof by Mr. J. C. Hunsaker. The pioneer experimental work of Eiffel should certainly find a place in any aeronautical library pretending to completeness. The committee representing the public and other libraries in Glasgow announces that this aeronautical list is to be the first of a series dealing with special subjects, and that the second of the series will deal with the internal-combustion engine. Other libraries would do well to follow Glasgow's example, for the catalogues ordinarily issued are of very little use as reference lists for any particular subject, and the increasing number of technical readers has created a demand for a convenient means of reference to technical subjects.

A COPY has been received of the calendar for the present session of the Merchant Venturers' Technical College, in which the faculty of engineering of the University of Bristol is provided and maintained. Among the varied and comprehensive arrangements explained in the calendar we note the Bristol "sandwich" scheme of training for engineers. The method is optional. The total length of the course is five years, of which about half is spent in the University and the rest in a works. Fourteen months are spent in a works at the end of the first session, and these enable a student to return to the University better qualified to understand the theory of engineering and the laboratory work than if he had had no such experience. Two months of the third year and