The following short selection of papers gives some idea of the type of work carried on with the 1 MV. set; the work described in them was in whole or part dependent on this apparatus.

Excitation of γ-Radiation in Processes of Proton Capture by Light Elements (Curran, Dee and Petrzilka), *Proc. Roy. Soc.*, A, **169**, 269 (1938).

A Further Study of Nuclear Isomerism (Feather and Dunworth), *Proc. Roy. Soc.*, A, **168**, 566 (1938).

Resonance Phenomena in the Disintegration of Fluorine by Protons (Burcham and Devons), *Proc. Roy. Soc.*, A, **173**, 555 (1939).

Disintegration of Boron by Slow Neutrons (Bower, Bretscher and Gilbert), *Proc. Camb. Phil. Soc.*, **34**, 290 (1938).

Experiments on the Transmutation of Sodium by Deuterons (Murrell and Smith), *Proc. Roy. Soc.*, A, **173**, 410 (1939).

Fission Fragment Tracks in Photographic Plates (Green and Livesey), *Nature*, **158**, 272 (1946).

Short-lived Radioactivity from Lithium Bombarded with Neutrons (Poole and Paul), *Nature*, **158**, 482 (1946).

Upper Limits of Fission Cross-Section of Lead and Bismuth (Broda and Wright), *Nature*, **158**, 872 (1946).

Disintegration of Magnesium and Aluminium by Deuterons (Allan and Clavier), *Nature*, **158**, 832 (1946).

Interaction of Fast Neutrons with Beryllium and Aluminium (Allen, Burcham and Wilkinson), *Nature*, **159**, 473 (1947).

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PULVERIZED FUEL

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THE success of the Conference on Pulverized Fuel held at Harrogate during June 3–6 under the auspices of the Institute of Fuel clearly shows the interest now being taken in this method of firing. Its importance is evident from the accompanying table, which indicates the rapid increase that has taken place in the annual consumption of pulverized coal in Great Britain, particularly by the large electricity undertakings, which, it is estimated, will use 10 million tons per annum by 1950.

CONSUMPTION OF PULVERIZED COAL IN GREAT BRITAIN (THOUSAND TONS)

Year	Steam raising		Process work		Total, all users
	Electricity under-takings	Industrial	Cement and other kilns	Metal-lurgical furnaces	
1929	714	755	1,244	41	2,754
1939	2,410	1,602	2,222	303	6,537
1946	5,066	1,904	1,975	361	9,306

The smaller increases recorded by other users between 1939 and 1946 may have been due in part to the difficulty of obtaining new machinery during that period.

For most industrial purposes coal is by no means the best fuel; but, even at present prices, it is still the cheapest. It is therefore used, whenever practicable, in all processes in which the cost of fuel is a large proportion of the total cost of the product. Where fuel costs are not an important item, cleaner and more easily controlled fuels, such as gas or oil, will be used.

The advantages of pulverizing coal, that is, grinding it to a fine powder, of which as a rule about 80 per cent will pass through a 200 B.S. sieve, arise fundamentally from the fact that it can then be carried in suspension in a stream of air, thus conferring upon it some of the advantages of liquid or gaseous fuels. It can also be burned in suspension, which makes it particularly suitable for certain metallurgical processes requiring an intense luminous flame, and also for very large boilers, where the use of moving parts exposed to high temperatures is most undesirable. Its principal advantage, however, is that it makes it possible to burn efficiently low-grade small coal which is not otherwise easily disposed of, but which is being produced in ever-increasing quantities under modern mining conditions.

Against these advantages must be offset the considerable cost of providing and running the necessary grinding and other auxiliary equipment, and above all the many extra costs and difficulties arising from the inevitable presence of ash in the fuel.

Ash dominates the whole process of utilizing pulverized coal. In the first place, it represents so much useless material which is transported, at the same price as the coal, from the mine to the user and which is ground with the coal, so reducing the output of the mill and causing most of the wear and tear in the system. Secondly, it influences combustion chamber design more than does the process of combustion itself; and finally, after the useful fuel has been burned, the ash has to be collected with difficulty from the flue gases and, after collection, disposed of with equal difficulty. It is no exaggeration to say that the whole history of the development of pulverized fuel firing is that of a struggle for the mastery of ash.

In 1946 the percentage of ash in most of the coal pulverized at power stations and in cement mills in Great Britain was between 14 and 18 per cent. About three quarters of it could have been removed by known cleaning processes. Why then was the coal not cleaned at the collieries, thus eliminating some of the troubles just mentioned ? The immediate answer is that sufficient coal-cleaning plant is not at present available. Should it become available in the future the answer will depend upon economics, taking into account the price structure at that time. It must be borne in mind that to clean very fine coals it is necessary to wet them, and this involves adding the cost of drying to that of pulverizing. In any event, no cleaning process removes the inherent ash, and this would still have to be dealt with by the user.

Pulverized fuel firing was first used on a large scale in the cement industry in the United States so long ago as 1894, when it was applied to large rotary kilns. Its success was due to the fact that the kilns provided a combustion chamber of the ideal shape and size for burning poorly prepared fuel, with a burner of elementary design. The ash problem did not arise; indeed, the ash was sold as part of the product.

Other applications lagged far behind and were hindered partly by a general lack of knowledge, but mainly because pulverized fuel was regarded solely as a means of utilizing very dirty slack coal. Progress, however, has been such that reliable commercial apparatus is now available which will enable pulverized fuel to be burned efficiently in plant ranging in size from the small metallurgical furnace and the Lancashire boiler to the modern power station boiler which evaporates hundreds of thousands of pounds of steam per hour. Technical development is now directed towards the simplification of plant and its operation, and to the reduction of capital and running costs.

The trend towards simplicity may be illustrated by the fact that the bin-and-feeder system has been largely displaced by the unit system. At one time the processes of drying and grinding were carried out in separate apparatus, and the ground coal was delivered to a storage bin which smoothed out inequalities of supply and demand. The coal was extracted from the bin by feeders and carried to the burner by an air supply the quantity of which was determined by combustion conditions. With the modern unit system there is no reserve between the mill and the burner. The feed is controlled at the entrance to the mill, in which the coal is not only ground but also dried by means of hot air, possibly supplemented by hot gases drawn from the combustion chamber. The same air carries the pulverized fuel to the burners.

It will be realized that the simplicity of the unit system involves some sacrifice of flexibility, but power stations are using it successfully with a range f fuels containing from 10 per cent to 35 per cent of volatile matter. The bin-and-feeder system continues to be used in power stations burning anthracite, where combustion conditions require a smaller percentage of primary air than can be used with the unit system.

The mills now in use can be divided into three main groups: the slow-speed ball mill, mostly used in the cement industry, the medium-speed ring-roller and ring-ball types, which are predominant in power stations, and the high-speed impact and attrition types, which have a relatively low capital cost and are used in many small installations.

Apart from the effect of ash, which has already been mentioned, the principal source of reduced mill output is the presence of too much moisture; this hould not exceed about 10 per cent if full output is to be maintained. Generally speaking, the drying capacity should be sufficient to reduce the moisture in the coal to within 1 per cent of its inherent moisture.

When powdered fuel was first applied to water-tube boilers, the existing combustion chambers were far too small to permit the air-borne fuel particles to be ignited and completely burned before being carried among the convection heating surfaces, where combustion was checked. To reduce the consequent heat losses, the combustion chambers were increased many times in size, and this was one of the main factors leading to the successful use of pulverized coal.

With modern equipment, such large chambers are not required to obtain complete combustion. If this were the sole consideration, their size could be materially reduced. They are, however, retained in order to reduce the temperature of the ash particles below their fusion point before they enter the convection heating surfaces, where fused ash may give rise to 'birdsnesting', which may rapidly put a boiler out of commission. Indeed, the modern water-tube boiler can be described as a combustion chamber, of which the walls absorb by radiation up to 80 per cent of the heat developed, followed by an economizer and an air heater.

With pulverized fuel firing, about 70–80 per cent of the ash in the fuel is carried out of the boiler by the products of combustion, compared with 20 per cent or even less with stoker firing. During recent years there have been developed in the United States various types of 'slag tap' or 'wet bottom' furnace from which at least 50 per cent of the ash is removed as liquid slag, which can be disposed of with relative ease. The method has obvious advantages, and in certain applications it enables coarser fuel to be used; but difficulties yet remain, and even in the United States, where conditions are more favourable, only 18 per cent of the boilers now on order have 'wet bottoms'.

One bright feature in connexion with pulverized fuel ash is that its composition and quantity are such as to enable a boiler to be kept relatively free from external deposits and to be maintained at full load much longer than a stoker-fired boiler of the same size burning the same coals. In other words, a pulverized fuel boiler has a high 'availability', a factor of paramount importance at the present moment. Against this advantage is the fact that to discharge all the ash from a large pulverized-fuel boiler into the atmosphere would constitute an intolerable nuisance, and most of it must therefore be removed from the flue gases. To remove very fine dust from a gas is, however, an expensive process, which brings no compensating return to the user. Opinions naturally differ as to what is a reasonable efficiency to specify.

High efficiencies of dust removal can be obtained commercially with wet washers, electrostatic precipitators and some types of centrifugal separator. The electrostatic precipitator is usually preferred for powdered coal because of its ability to collect very fine particles without introducing water into the system, but very good results have recently been reported for a mechanical device consisting essentially of a large number of small cyclones. It has been suggested that the best results would be obtained with the two types in series, using the centrifugal apparatus to remove the large particles and to reduce the load on the electrostatic precipitator.

Various methods are used to remove the collected ash and to dump it either on land or at sea, and the possibility of using it for underground stowage is one argument in favour of building power stations at collieries. The dust has also been used as a filler and, with varying success, for brick making; but for such uses it has to compete with cheap and plentiful raw materials such as clay or sand.

Although in Great Britain and in the United States coal is the fuel most used in pulverized form, this method of firing is not restricted to coal. Hard pitch, for example, can be pulverized to give an excellent, almost ash-free fuel. In Germany large quantities of brown coal are pulverized, and practical solutions have been found to numerous special problems, some of which differ considerably from those encountered with bituminous coal.

With regard to future developments, although the use of pulverized coal is firmly established, design is far from stabilized; and there is room for continued research and development at all stages of preparation and utilization. Thus, existing mills absorb many times the power theoretically necessary to give the required increase in the surface area of the coal; burner and combustion-chamber design could be improved to give better ignition and combustion; radiant heat is transferred more efficiently to some parts of the combustion chamber walls than to others; while the scope for improvement in dealing with the many aspects of the ash problem is almost unlimited.

New applications for pulverized fuel may also be found, but they must show a saving in overall costs before they can compete with oil, which has all the advantages of pulverized fuel without most of its disadvantages. Thus internal combustion engines can be designed to use pulverized coal, but they are not likely to displace oil-fired engines. Similarly, technical success has been achieved in firing marine boilers with pulverized coal, but it has failed to check the tendency to change over from coal to oil. On the other hand, work now in progress in Switzerland and in the United States suggests that it may find a new field in the gas turbine, for both stationary use and for locomotives. It is particularly interesting to learn that it is expected that two full-scale gas turbine locomotives using pulverized fuel will be in operation in the United States by next spring.

INTERNATIONAL CONFERENCE FOR THE PROTECTION OF NATURE

AN International Conference for the Protection of Nature was held at Brunnen, Switzerland, during June 28–July 3, and was attended by sixty-six delegates representing twenty-two countries. Dr. Charles Jean Bernard, president of the Swiss League for the Protection of Nature, was elected president of the Conference, and Prof. Maurice Caullery and Dr. J. Ramsbottom were elected vice-presidents.

It was soon apparent that there was a divergence of opinion concerning both the status of the Conference and the effective steps which could be taken to fulfil its purpose. Many delegates apparently were authorized by their respective Governments to give assent to a draft constitution establishing a permanent inter-governmental Union, whereas others had no official status, as they merely represented societies.

The present position can best be understood from a summary of what had previously occurred. At the Eighth International Zoological Congress at Graz in 1910, Dr. Paul Sarasin raised the question of world-wide Nature protection. A committee was formed which requested the Swiss Government to convene an International Conference. This Conference was held at Berne in 1913, and established an Advisory Commission for the International Protection of Nature, with its centre at Basle. A draft convention was drawn up and signed by the delegates of the seventeen countries represented, but the outbreak of war left it in the air as only nine countries had then ratified it, though five additional signatures were added by December 1914. An attempt was made to revive the Commission at the First International Conference for the Protection of Nature held at Paris in 1923, but failed, presumably because the signatories included ex-enemy countries, whereas Great Britain, France and the United States had not ratified it. In 1928 an International Office for the Protection of Nature was started at Brussels, sponsored by the Governments of France, Belgium, Belgian Congo, Netherlands, Netherlands Indies, Poland and Germany; the Office, which acts as a central office for information, was transferred to the Colonial Institute at Amsterdam in 1945. During the War it suffered many vicissitudes, but is now resuming its activities.

Mention should also be made of the Convention for the Protection of the Fauna and Flora of Africa, resulting from the London Conference of 1933, and a similar one for the Americas; the International Committee for Bird Preservation; and the international agreement preventing the over-fishing of whales.

The Swiss League invited a number of representatives of interested foreign societies to visit the Swiss National Park and other Nature reserves in 1946. So good a response was received that they decided to hold a meeting at Basle, when opportunity was taken to discuss general problems. The necessity for an active organisation was agreed upon, and the Swiss League was asked to arrange an International Conference this year. The difficulties of doing this were apparently not at first realized.

When invitations were received in Great Britain, the Society for the Promotion of Nature Reserves called meetings of representatives of interested societies and discussed the various points which needed clarification. M. J. Büttikofer, secretary of the Swiss League, attended the first meeting and gave an account of the League's general attitude and Dr. J. H. Westermann a second one, and explained the present position of the International Office. There was unanimous agreement that the Conference called for Brunnen, if held, could be regarded only as exploratory, and that the United Nations Educational, Scientific and Cultural Organisation should be asked to call an International Congress at Paris next year. Their view was later embodied in a series of motions which the British delegates (J. Ramsbottom, N. D. Riley, the Hon. Miriam Rothschild and G. F. Herbert Smith) presented to the Conference.

It was obvious that if a decision were taken immediately the Conference might end with its first meeting, for the delegates were apparently equally divided regarding the authority of the Conference to adopt an international code. It was agreed, therefore, to leave all debatable matters to the final session and to proceed with the drawing up of a draft constitution. A drafting committee was set up under the chairmanship of Dr. G. F. H. Smith. The draft constitution was finally adopted unanimously. Of the nine articles, only that dealing with objects and functions is of immediate interest. This reads

(1) The Union shall encourage and facilitate inter national co-operation between Governments, national and international organisations and persons interested in the protection of Nature and natural scenery.

(2) The Union shall promote and recommend national or international action in respect to: (*a*) scientific research relating to the protection of Nature; (*b*) the spread of public knowledge about the protection of Nature; (*c*) the improvement of educational methods best suited to teach the people of the world and especially the children the importance of the protection of Nature; (*d*) co-operation for regional planning with due regard to the principles of the protection of Nature; (*e*) the creation and conservation of national parks, Nature reserves and natural scenery; (*f*) the preservation of wild life and its natural environments; (*g*) the preparation of a world-wide convention for the protection of Nature.

(3) The Union shall collect, analyse, interpret and disseminate information about the protection of Nature.

(4) The Union shall publish and distribute to Governments, national or international organisations concerned with and persons interested in the protection of Nature, documents, legislative texts, scientific studies and information of any kind regarding the protection of Nature and especially the preservation of fauna, flora, natural scenery and natural monuments.