auxin produced by algae. This appears to be an unstable water-soluble auxin complex which breaks down to at least two inter-convertible biologically active compounds, which are possibly indole compounds.

The investigations reported in this article are continuing and will be published in detail elsewhere. They have been carried out during the tenure of a Senior Government Research Fellowship, and I am indebted to the Director of the Scottish Home Department Marine Laboratory for facilities for the work.

[1] Lucas, C. E., "Marine Biology and Oceanography", 139 (Pergamon Press, Ltd., London, 1956).
[2] Bentley, J. A., "States of Auxin in the Plant", *Encyclopedia of Plant Physiol.*, 14 (1958) (Springer-Verlag, Berlin) (in the press).
[3] Bentley, J. A., and Housley, S., *Physiol. Plant*, 7, 405 (1954).
[4] Vlitos, A. J., Meudt, W., and Beimler, R., *Contrib. Boyce Thompson Inst.*, 18, 283 (1956).
[5] Britton, G., Housley, S., and Bentley, J. A., *J. Exp. Bot.*, 7, 239 (1956).
[6] Algeus, S., *Bot. Notiser* (*Lund*), 9, 129 (1946).

POWER DEVELOPMENT IN HITHERTO UNDER-DEVELOPED COUNTRIES

THE eleventh sectional meeting of the World Power Conference, held in Belgrade in June 1957, took as its theme "Power as a Factor of Development in Undeveloped Countries". It is a sign of the awakened interest of these countries in their economic and industrial development that the entire programme of a meeting should be devoted to this subject. The reports, which unfortunately were not generally available in Great Britain for some months after the meeting was held, can conveniently be divided into six sections: (*a*) the economics of power as a factor of development; (*b*) multi-purpose utilization of water courses; (*c*) the use of low-grade fuels; (*d*) nuclear power plants and undeveloped countries; (*e*) power and agriculture; (*f*) power for metallurgical, chemical and allied industries. It is not possible here to do more than indicate the lines of thought and to note items of outstanding interest in the papers, most of which have been published in English, though a considerable number are in French or Russian.

Under the heading of section (*a*) some thirty-eight reports deal with the economic aspects of power and its various ramifications of supply and distribution. There is considerable discussion of what parameter should be adopted to define or to correlate the state of backwardness of an undeveloped country. Power consumption per head would seem to be among the most reasonable. For example, the consumption of power in metric tons of coal per head is 8·18 in the United States, 4·58 in the United Kingdom, 3·14 in Germany and 2·59 in France, whereas it is 0·65 in Yugoslavia, 0·35 in India and 0·27 in Burma. There is a temptation to ascribe backwardness to lack of natural resources, but analysis shows that while the developed countries own only some 50 per cent of the world's coal reserves, 30 per cent of the oil reserves and 25 per cent of the available water-power, they are responsible for more than 70 per cent of the world's output of energy. Whether it is true, as one author suggests, that "this stagnation or low level of production has been brought about by various historical and international causes and under no circumstances has it been a sheer result of lack of natural resources or inertness of the native population" is arguable, bearing in mind Middle Eastern, African and South American experiences; as several other authors state, it seems more likely that backwardness is due to low capital formation.

It is generally agreed by both Eastern and Western authors that power production is so fundamental in the economy of a country that the planning of the development of power resources should be carried out on a national scale, and that the "social economic infra-structure", that is to say, nationalized concerns which in Western countries have been built on the foundation of individual enterprises, should be the foundation, not the crown, of commercial undertakings. The suggestion is made that there is no necessity for undeveloped countries to adopt the programme followed by the older industrialized countries in achieving industrialization, which in the past sometimes involved "immiseration of the working people". There is no reason why old mistakes should not be avoided and industrialization attained much more rapidly by planning on a national or even international scale. Seven of the papers in this section deal with the relation between the consumption of energy and national reserves; Belgium, Japan, Norway, Spain and Sweden are among the countries treated in this way. Various equations are derived for correlating revenue or production with energy consumption.

The policy to be adopted in the development and use of power is fully discussed. One paper points out that a 1 per cent increase of production is likely to require a 2·3 per cent increase of energy, and goes on to show how in Britain it costs more to transmit 1 kWh. of electricity 500 miles than to transport the coal required for equivalent power production 500 miles by rail. It is, however, cheaper to transport the coal 500 miles by water than to transmit the electrical power. Various industries show very different requirements of coal per £1,000 of finished products, the steel industry requiring 90 tons, the motor industry 6·1 tons and the clothing industry 1·7 tons.

Comments in a paper from a Greek source emphasize the importance of designing a power system right from the start so that there is integration of hydro, thermal and nuclear resources. Czechoslovak experience gives priority to the building of hydro-plants, since such projects can be combined with irrigation. Costs of financing large schemes seem to favour the more developed countries; the financial burden of paying off the loan per kW. capacity is quoted as 7,000 fr. in the United States, 10,000 fr. in France, and 25,000 fr. in Tunisia. Presumably the cost of building power plants should be less in undeveloped countries with surplus man-power. The problem of the application of internal combustion engines to local use in areas when the load factor is low is touched on in two papers, one of which suggests that when the load factor is less than 30 per cent it might be more profitable to complete the network by Diesel generators of about 1,000 kW. capacity; the other paper treats the use of engines of up to 50 h.p. under primitive conditions.

An unusual problem is faced in Iceland. Here, thanks to natural resources of hydro and geothermal energy, at least 300 MW. of electrical energy could be produced surplus to local requirements. This surplus could be exported (to Scotland) by submarine cable, or used to satisfy an aluminium or chemical industry. Development of each scheme requires capital beyond Icelandic resources. The same situation occurs in the Cameroons, where the surplus hydro capacity is already being put to use producing aluminium to relieve the load in France.

Six reports discuss hydro-plant economics. Data are given of the results of the Grand Coulee and North Platte river schemes, where population has increased by twenty- and twenty-seven-fold, respectively, and the value of produce by ten and thirteen times. Russian estimates place the present output of the developing hydro systems of Uzbekistan at 480 MW. from 580 plants.

There are three reports on the economics of nuclear energy. In the first, from Britain, it is argued that at present the development of hydro-electric power is likely to be the most economic when suitable potential exists, but that if the plants exceed 100 MW. capacity, nuclear plants can compete with thermal plants, unless the load factor is low. In the second report, from Italy, the conclusion is that the building of nuclear plant is likely to be profitable only when the cost of imported fuel and the load factor are both high. The third paper, from Japan but dealing with the under-developed portions of the East, suggests that these countries should first build up their consumption of 'conventional' energy until it is high enough to permit the application of nuclear forms.

Among other subjects discussed are the mathematical solution of the economic relationship between hydro-electric and thermal plants in a given system and the most rational installed power capacity of hydro-electric plant for a given flow-duration curve. The problem of meeting loads in excess of the hydro-output—it is generally agreed that steam plants are most economical for supplementing a long-term excess load, but that gas turbines and Diesel engines are preferable for short peak periods—and the division of costs between different consumers in multi-purpose schemes are also examined. Few technical data are provided of actual machinery, but one Russian paper describing the progress in the construction of water turbines in the U.S.S.R. states that Russian industry is now manufacturing a unit of 272,000 h.p. and another of 400,000 h.p. for use on Siberian rivers. A novel suggestion is made for storing compressed air in underground water-bearing strata for eventual use in gas turbines.

In section (*b*) forty-one papers from seventeen countries deal with the multi-purpose utilization of water courses. Most of the papers treat problems in the context of those countries, often highly developed, from which they originate; none the less, the information is valuable for more general use. Any discussion of water resources involves the question of the most economic division of these resources between the conflicting requirements of power production, irrigation, transport and municipal supply. The situation is further complicated by the variation of the available discharge. Most discharges have two maxima and two minima. Waters originating in mountain snow-deposits have higher discharges in summer than in winter, with a winter minimum lower than the summer minimum; for water originating from rains, the converse is usually true. The problem is to tie in these variations with irrigation demands, which are usually greatest in the spring, and power requirements, which are seasonally relatively constant but fluctuate over a daily cycle. Papers describing the situation in southern Italy, where the demands for both irrigation and power are greatly in excess of supply, blame old methods of irrigation which divert water before the points of power utilization, and suggest that storage basins should be erected in streamless valleys. During the night there are certain surpluses of power, so that water could be raised to suitable reservoirs to supply the irrigation networks. The same problems apply to the use of the River L'Oum Er Rbija in Morocco, but here the most important consideration is irrigation. Data are provided of the development of the valley of the Murray River in Australia by swamp reclamation, of the multi-purpose control of the waters of the Missouri, Arkansas, White and Red Rivers in the United States, of the results achieved so far in the Uzbek by the harnessing of the Rivers Sir Darja and Amu Darja flowing into the Aral Sea, of the works on the Dneiper, and on the Kama and Volga, the last two to have an installed capacity of 11,000 MW.

Whereas large developments are proceeding in some countries, others have almost engaged their potential. Japan will shortly have no more water-power to exploit, and will have to turn to thermal and nuclear plant, but hydro-electric plants with storage basins will meet the requirements of peak-load periods. Spain expects to engage all her 9,000 MW. within twenty years. She feels that international exchange of power and possibly even diversion of streams is desirable when rivers flow across national frontiers. Experiments similar to those carried out in Australia have been conducted in Spain on rain-making by seeding clouds over the Pyrenees with silver iodide. The estimated result was 600 million cubic metres of water at a cost of 0·0005 peseta per cubic metre.

Nineteen papers were presented in section (*c*), all from industrialized countries. A world survey suggests that the ratio of high-quality coal to low-grade fuel is decreasing steadily. As high-grade coal fuels are also valuable chemicals as part of metallurgical processes, firing such a fuel merely to produce heat and electricity is the most uneconomic way of using it. Most countries, therefore, are giving much thought to the winning, processing and burning of high ash-content coals, lignites, brown coals, peat and oil shale. New European power plants are now commonly designed to burn such low-grade fuels, which amount to more than 85 per cent of the total European production. In the U.S.S.R., 75 per cent of the electrical power produced thermally is derived from some form of low-grade coal. As world electricity consumption is increasing annually at about 7 per cent (in Europe 12 per cent and in the U.S.S.R. 15 per cent) it is evident that facility in consuming poor fuels efficiently is urgently required.

Lignites (coals with 45–60 per cent water content) can be fired on grates in layers or pulverized in combustion chambers. New installations almost all employ pulverization; the drying process may be carried out during the pulverizing process or separately according to whether a closed or open circuit is used. The pulverizing process may be carried out in various forms of mills, hammer mills being suitable for lignites of high moisture content. As with lignites, so brown and hard coals, slack and peat can be burned successfully, particularly if pulverized. Peat is especially important in the U.S.S.R., which possesses large reserves and which consumed 50 million tons in 1956. Some of this peat is burned in boilers or chain grates and the rest pulverized by ball mills and dried by heated air burned in cyclone furnaces. No mention is made of peat consumption in gas turbines.

Oil shale occurs in large quantities, often in countries possessing no oil wells. By processing the shale in retorts, about half the organic matter present may be converted to liquid fuel of relatively poor quality. Progress has therefore been made in burning shale directly. In Israel it is coarsely ground in hammer mills and in the U.S.S.R. in ball mills and fired through burners.

Except for a new Czechoslovak two-pass combustion chamber which, it is claimed, will burn all kinds of low-grade fuel of high moisture and mineral content, no new techniques are discussed, but evidently the technology of low-grade fuel combustion is rapidly being mastered.

Section (*d*) dealt with nuclear power plant and undeveloped countries. In the present state of development of nuclear reactors, one of the first requisites for countries lacking experience in their use is to obtain some form of reactor purely as an instrument for training their future technical staff, there being no substitute for practical experience. There is no general agreement yet about the best type of reactor for undeveloped countries, though certain types are obviously unsuitable. Thus, the fast breeder reactor requires too much enriched uranium or plutonium, necessitating high capital expenditure, so that as a small·plant this reactor must operate at a very high load factor. A British paper suggests that the aqueous homogeneous reactor, the boiling-water reactor, the organic-moderated reactor and the water-cooled graphite reactor are unsuited by reasons of complication or economy in large under-developed countries, and that countries with large unexploited potentials of fossil fuel in some areas, but with other areas remote from natural fuel supply, would do well to adopt the graphite-moderated, gas-cooled reactor, as has been the policy in the United Kingdom and France. A fuel supply of natural uranium is always likely to be more readily available than enriched uranium. The same paper suggests that small countries should consider the boiling-water reactor or the pressurized-water reactor. Considerable experience has been gained on these and they may be built in packaged units. A paper from the United States also put forward the view that the pressurized-water reactor, as supplied in the *Nautilus*, might be suitable for small countries, and discusses the design of two such plants, one of 11·5 MW. and the other of 143 MW. electrical output. Another American paper supports the use of organic-liquid moderated reactors, using slightly enriched uranium fuel elements. Organic liquids cause little corrosion, do not usually have to be pressurized, have negative temperature coefficients and sustain little induced radioactivity. The major problem is the instability of the organic polyphenyls. Experience is still being gained on a prototype.

After the comments from would-be seller countries, it is interesting to note the Spanish contribution. In Spain it is hoped to begin installation of full-scale plant in 1965, and that by 1970 the installed nuclear power will be 350 MW. Spain possesses sufficient uranium ore to anticipate an annual output of some hundreds of tons. Attention has been focused on those types of reactors on which practical experience has been gained, though in Spanish opinion no experience is as yet very great. The capital cost of Spain's first reactor must be low, and it will be used for training purposes. With these factors in mind, the graphite-moderated reactor is regarded as far too costly, and attention has been directed to the boiling-water and pressurized-water types. As, however, immense pressure vessels cannot be manufactured in Spain, the boiling-water reactor, using heavy water, is likely to be the prototype. When experience has been gained, it is intended that the graphite-moderated reactors will be reconsidered.

There were fifty-five papers in section (*e*), dealing with the effects of power on the social and economic structure of rural communities, methods of producing power, rural electrification, generation and distribution of electricity, internal installations and research on rural electrification.

One effect of electrification on rural social life is often a complete and sudden breakdown of centuries of isolation through the media of television and radio. In the Ardennes, rural electrification has largely checked the flow of population to the towns and has increased milk and vegetable production. The results of electrification in southern Italy are discussed; some idea of the magnitude of the task in India is gained from the fact that 290 million out of 356 million people live in villages, of which only 0·5 per cent are supplied with electricity.

The best use of internal combustion engines of types varying from the long-lasting horizontal single-cylinder oil engine to the open-cycle gas turbine is explained in a British paper, and a Yugoslav contribution compares the costs of electric and internal combustion motors, in favour of the electric motor.

Many papers discuss the increase of productivity with electrification. A good general analysis from world-wide results show that productivity with and without mechanization varies between 3·3 : 1 and 15 : 1. Of interest also is the requirement of keeping the cost of generating and distributing power low. Prefabricated concrete elements are used in building hydro-electric plant in the U.S.S.R.; Japan has installed 4,500 small hydro-electric plants of 1,700,000 kW. total capacity. For economy in rural transmission the Russians use steel cable, reinforced concrete posts, the earth as a conductor wherever possible, three-phase nets of high voltage with completely prefabricated transformer stations. In Sweden, experiments are being conducted on the use of polyvinyl cable to reduce the cost of the new installations. India's practice is to use 11-kV. single-phase systems with the earth as a conductor, aluminium–steel or aluminium cables, with wooden or prestressed concrete poles.

Large-scale chemical and metallurgical plant, which play a vital part in the build-up of industry, were considered in section (*f*). Various papers discuss the lay-out of plant components and the recovery of waste heat from the combustion gases, hot air and red-hot products. One suggestion is that the most economical way of recovering waste heat in a metallurgical plant is by the use of a back-pressure gas turbine, a view supported elsewhere. A Russian paper describes the Kuznetzk metallurgical combine, and shows how a desert region of Western Siberia was transformed in twenty-five years into an industrial centre of 400,000 inhabitants. The site is 400 miles from the nearest large town and endures a winter temperature of − 50° C. About 50 per cent of the electric power of the plant is obtained from waste products. The town is supplied with waste heat and gas from the coking plant. Other industries, for example, a cement factory and a food-processing works, are integrated with the combine.

The question of the best method of using power for metal production attracted some interest. One paper describes the methods of production of the light metals, aluminium, magnesium, titanium and beryllium, both by electrolytic and thermal processes; another, the production of ferro alloys (silicon, chromium, manganese); and a third the economics of producing pig-iron and steel electrically. As a rough rule, it is stated that economic equilibrium is attained between blast and electric furnaces for pig-iron production when the price of 1 kgm. of coal is about five times greater than the price of 1 kWh. of electricity. For countries with a surplus of water-power the electrolytic production of hydrogen is suggested. This can be used as a raw material in nitrogen factories for fertilizer and other chemicals. The electrolysis of water at 30 atmospheres is described as being very efficient and requiring few personnel.

Generally the suggestion is that countries with large resources of power, particularly hydro-power, should encourage the construction of a large integrated metallurgical industry.

The Conference reviewed many aspects of development and much detailed information is published. There is little that is completely new except for the desire of the backward countries, now gradually being realized, to equip themselves with power resources. There was a growing awareness that many problems can only be solved by international co-operation, and that the world is becoming a single economic unit. The day must come when national power systems become international systems and international systems become continental power grids.

F. D. Robinson

OBITUARIES

Dr. G. A. Steven

George Alexander Steven, whose death occurred on April 7 at his home in Yelverton, South Devon, was born at Freswick, Caithness, on April 13, 1901. He was an undergraduate at the University of Edinburgh during 1924–28, being Vans Dunlop Scholar in 1926. He was appointed student probationer at the Plymouth Laboratory of the Marine Biological Association of the United Kingdom in 1928, and joined the permanent staff of the Laboratory in 1929.

Steven, who had practical experience of the sea and fishing in his youth, studied chiefly the biology of commercial fishes, especially the rays and skates and the mackerel. His comprehensive survey of the biology and fishery of the mackerel in the English Channel and its western approaches formed a noteworthy contribution to our knowledge of that species. He also undertook special investigations to assess the possible damage to local fisheries in Devon and Cornwall by seals, and shags and cormorants. In the study of seals he visited all the likely caves on the north coast of Cornwall and made a census of the population.

In 1939 he accepted the post of director of the Newfoundland Fisheries Research Laboratory at St. Johns, in succession to Dr. Harold Thompson. Almost immediately, however, the St. Johns Laboratory was destroyed by fire, and further activities were curtailed by the outbreak of war. After his war service he decided to remain on the staff of the Plymouth Laboratory.

Steven saw service with the Expeditionary Force in France in the First World War, and in the Second World War he served in the Royal Navy. During 1942–45 he was seconded from the Navy to act as fishery development officer of Sierra Leone under the Colonial Office. He was based at Freetown, and under the many difficulties created by the circumstances of war he helped to lay the foundations for post-war fisheries development in West Africa.

His practical knowledge of fishing vessels was put to good use in the assistance he gave in the design and equipment of the Association's research vessel *Sarsia*. His interest in fishing gear led to the writing of a small book entitled "Nets: How to Make, Mend and Preserve Them", which proved very successful. During 1930–40 and 1946–48 he took part in the supervision of the university students' Easter courses at the Plymouth Laboratory. Steven was a D.Sc. of the University of Edinburgh and Fellow of the Royal Society of Edinburgh.

The sympathy of his many friends will go to his widow and two sons.

F. S. Russell

Mr. Frank Kingdon-Ward, O.B.E.

With the passing of Frank Kingdon-Ward on April 8, at the age of seventy-two, the last of the great plant collectors and explorers in the Forrest–Farrar tradition has left the scene. It is now no longer possible for westerners to travel alone for months in the vast areas of Tibet, north Burma and western China, where many of the best of the plants now cultivated in our gardens are to be found in their native habitats. Perhaps the artificial barriers which now block the way will one day be lifted but, in any event, conditions have changed. The aeroplane saves weeks of foot-slogging, and modern medicine provides the prophylaxis to keep the traveller fit. No doubt soon the helicopter will deposit the plant collector on the tops of mountains which it would otherwise have taken months to reach.

Those who are prepared to accept the penalties of one-man exploration—the physical hardship, the utter loneliness of months in a strange land among strange people, the nauseating dullness of a diet of tsampa washed down with rancid butter tea and all the inconvenience of travelling 'light', must possess exceptional courage, determination, loyalty to their sponsors and devotion to their purpose. These qualities, combined with modesty—for all the great explorers were modest men—are qualities which make men great and Kingdon-Ward possessed them in full measure. He was no mere explorer and plant collector. It is true that his contributions to our knowledge of the geography of Tibet, north Burma