in establishing the isostatic theory on a firm basis. This point, for which there is no direct evidence in the Norwegian case, is to the effect that the tilting of the Great Lakes region was in progress before and during the rise of the sea in the Ottawa valley, for, presumably from a comparison of contemporaneous ice-margins, it is concluded that "the Ottawa valley must have been, in part at least, occupied by the ice-sheet during the existence of Lakes Iroquois and Algonquin, and at least a small amount of uplift affected the region at the foot of Lake Ontario during the life of Lake Iroquois. Uplift also affected the northern portion of the Great Lakes region, and probably included the upper portion of the Ottawa valley near Mattawa during the existence of Lake Algonquin, and while the ice-sheet still occupied the upper portion of the Ottawa valley." Further, it is not a case of alternating elevation and depression, "for the result of investigations by numerous geologists of the raised beaches of the Great Lakes region has shown that differential uplift took place almost continuously as the ice withdrew."

We have thus direct proof that a district which was rising relatively to those around it was nevertheless undergoing submergence beneath the level of the sea. This remarkable phenomenon can have but one explanation, namely, that the isostatic recovery and the general rise of the ocean-level were in progress simultaneously, and that for a time the latter was the more rapid. Norway up to the present has only supplied a measure of the difference of these two motions. To presume their concerted action was a leap in the dark. Canada has now produced unexpected evidence of their individual existence.

There is now but one thing wanting to make the analogy between the isostatic phenomena of America and Europe perfect in every detail, and that is the discovery of a shore-line corresponding to the "Early Neolithic" or "Littorina-Tapes" raised beaches of Great Britain and Scandinavia. This should represent in the south a distinct resubmergence, and in the north a pronounced check or slowing down in the general emergence.

W. B. WRIGHT.

PLANT DISEASES.

THE *rôle* played by insects in the spread of plant diseases is well brought out in the case of the collar-rot of rubber trees (*Hevea brasiliensis*), recently investigated by Sharples (Bull. 25, Dept. of Agriculture, Federated Malay States, 1916). The disease is caused by the fungus *Ustulina zonata*, as Brooks (Bull. 22, F.M.S.) has already shown. Sharples finds that at the time when the trees in a young rubber plantation are thinned out, at the age of about six or seven years, attacks by boring beetles (*Xyleborus parvulus*) become very common. He shows that these insects easily enter trees the bark of which has been injured by the falling of one tree against another. Attacks by the above-mentioned fungus usually quickly follow the beetles which enter rubber trees, the tracks of the insects being convenient ports of entry for the wound-parasite, *U. zonata*. At the time of thinning a large amount of suitable food material for the fungus is available in the form of soft rubber wood. Owing to the increased development of the fungus under these conditions in conjunction with the greater prevalence of borer attacks during the same period, it follows that the thinning-out stage is the most dangerous one in the life of a plantation as regards the attacks of this fungus on rubber trees.

To No. 10 of the twelfth volume of the *South African Journal of Science*, published in May of the present year, Dr. Ethel M. Doidge contributes a paper on the occurrence in South Africa of *Bacterium campestre*, the organism which causes the black-rot disease of the cabbage and other cruciferous crops. This organism had formerly been recorded only from Europe, America, and New Zealand, but Miss Doidge's investigations showed that the disease caused by it was quite common in the neighbourhood of Pretoria. The most interesting point about the communication is that it seems clear that the organism in the case under consideration was introduced into South Africa on cabbage seed which came from England. From cabbage seeds imported by the nuseryman to whose premises the diseased plants first observed by Miss Doidge were traced, the organism was isolated and its virulence proved by the successful artificial inoculation of two healthy cabbage plants. It was suggested nearly twenty years ago by Stewart in America that this disease was probably disseminated by seedsmen, but actual proof was then wanting. Soon after this the organism was isolated by Harding from the surface of cabbage seed produced by diseased plants in Long Island; and now Miss Doidge has shown that by such means the disease may be carried from one continent to another. Soaking suspected seed for fifteen minutes in 1 : 240 formalin or in 1 : 1000 mercuric chloride is recommended as a suitable method of treatment.

The cause of the serious disease of the potato known as the "Blattrollkrankheit" (leaf-roll disease) has been a matter of considerable controversy. The earlier investigators regarded the disease as being due to the choking of the wood-vessels of the plant with fungus mycelium. Recent researches, however, have shown that plants suffering from the choking of their vessels (*hadromycosis*) are not to be confounded with those affected with the true leaf-roll disease in which mycelium is absent. Quanjer, in 1913, found necrosis of the phloem to be a characteristic symptom of true leaf-roll in Holland; and in his most recent publication (*Med. van d. Rijks Hoogere Land-, Tuin- en Boschbouwschool,* Deel x., Wageningen, 1916) this author claims to have proved that the disease is due to a transmissible virus. Since attempts made to infect healthy potato plants by means of injections of the sap of diseased plants did not succeed, it might be thought that the claim is not justified. However, successful transmission of the disease was brought about in grafting experiments both with stalks and with tubers. Further evidence in favour of the virus is claimed to be afforded by the failure to isolate any parasitic organisms from affected plants, by the method of spread of the disease, by the uncertain results of selection as a means of raising healthy stocks of plants, and by the infection of healthy plants when transferred to diseased surroundings either through the agency of the soil (in which it is believed that the virus is often present) or from neighbouring diseased plants. It would seem that further research is necessary in order to supply absolutely convincing proof of the virus theory of the origin of this disease. Should it turn out to be a correct one, this disease, which has already made its appearance in some parts of Great Britain, will probably become more or less widespread in a few years unless some measures are taken to check it. The publication referred to is published in both the Dutch and the English languages.

COAL AND ITS ECONOMIC UTILISATION.[1]

THE economic importance of coal we perhaps realise. It is the only raw material we produce in great quantity; the value of our total mineral output in 1913 was above 160,000,000*l.*; of this the value of the coal at the mine was above 145,500,000*l.*

Our output of coal and our home consumption in

[1] Abridged from the Howard Lectures delivered before the Royal Society of Arts on November 27, December 4, and December 11, 1916, by Prof J. S. S. Brame.

the year 1913, a period undisturbed by domestic troubles or by the war, touched high-water mark in production and in consumption, with an output of 287,430,000 tons, of which 189,000,000 tons were retained for home use. The number of employees was 1,110,884, which gave an output per head of 259 tons.

In 1914 the output fell to 265½ million tons; in 1915 to 253 million tons. The demand for coal, however, increased with the enormous activity in the production of munitions, but the home consumption in 1914 was 184½ million tons, and about the same figure for 1915. It was therefore the export trade which suffered.

In the period of forty-two years, from 1873 to 1914, we have raised 8,206,243,000 tons, and exported 2,012,796,000 tons, or more than 24½ per cent. The value of the coal raised was equal to more than 84 per cent. of the value of our whole mineral output.

The questions arise naturally, What stocks have we? What inroads have we made on them? and How long will the stocks last? The last is too highly speculative and has too little real bearing on the question of economy to justify more than mention of the insuperable difficulties of making such an estimate.

Estimates of stock can, however, be made with some approximation.

The following estimate was made by the Royal Commission (1905), the figures being in million tons.

Estimated Coal Reserves, Royal Commission, 1905.

	Not exceeding 4000 ft.	From 4000–10,000 ft.
Proved	100,914 ...	5,239
Unproved	40,721 ...	—
Totals ...	141,635 ...	5,239

A few words may prove of interest about the Kent field, which was not included in the above estimate, and is of particular interest to us in London and of wider importance because of its geographical situation in relation to the North Sea and the Channel.

From borings which have gone to 2500 ft., Prof. H. S. Jevons considers it is established that over an area of 150 square miles the total thickness of the seams (of 18 in. and above) is from 30 to 40 ft. If the area is no greater than this—and there is reason to believe it is much more extensive—the reserves would be some 6000 million tons.

The composition of one class is very close to the average composition of the high-class Welsh smokeless coals. If the burning qualities of the coal are as good, and the seams are workable, the occurrence of such coal so conveniently situated in relation to several important naval bases may prove a valuable asset to the Royal Navy.

Comparison may be made between our reserves and those of other countries.

Of the European reserves, Germany possesses 54 per cent. of the whole; Great Britain 24 per cent.; Russia and Austria-Hungary about 7·6 per cent. each; and France 2·1 per cent.

Of the world's probable reserves, North America can claim nearly 69 per cent., of which approximately 40 per cent. lies in the United States. Asia comes next with 17·3 per cent., leaving Europe a poor third with about 10·5 per cent.

Not only are we exhausting our supplies at a far higher proportionate rate than our nearest commercial rivals, but we are retaining for our home use a much smaller proportion of the output.

It is clear that if Great Britain is to maintain her place among the great nations she must remain a great manufacturing centre, and this depends entirely on cheap fuel. The necessity for economy in place of waste is apparent, and enormous economies are undoubtedly possible.

One very important and very difficult question is that of export. It cannot be denied that in our export trade we have, to a large extent, developed our industrial greatness. But we must look at this question of export on a wider front than the immediate present or the immediate future. If, as our political economists tell us, our export is essential to our well-being, we must realise that it is at the cost of bringing the day rapidly nearer when industries will be hampered by dear coal—in other words, mortgaging the interests of posterity in the interest of the present and possibly a few succeeding generations.

The suggestion which has been made for the re-imposition of a duty on export coal, the proceeds from which should be applied to the investigation of our coals and the development of schemes for the more economical utilisation of the coal we consume, would appear very sound.

As Prof. H. S. Jevons so aptly puts it: "Englishmen must take heed in the future to rely less upon exploiting our vast stores of national wealth, and more upon the resources which scientific skill and practical education can place at our disposal."

The economic use of coal is closely associated with the question of the by-products—ammonium compounds and the tar—many important chemical industries being dependent on the latter, whilst the small quantity of nitrogen in coal—averaging about 1·4 per cent.—furnishes our principal supplies of ammonia compounds. The sulphate of ammonia alone is a most important material as a fertiliser, and its importance to agriculture can scarcely be over-estimated. In the increased production of home-grown foodstuffs, generally admitted to be a pressing question, it must undoubtedly prove an important factor. It is one of the romances of science that by means of sulphate of ammonia we are actually returning to plant life nitrogen derived from a previous vegetation which flourished millions of years ago.

The tar is the most important of the by-products obtained, and certainly no substance has yielded so many valuable products for the service of man. All the vast number of beautiful dyes, of valuable drugs, disinfectants, flavouring essences and perfumes, and photographic developers are the outcome of the work of the chemist on the raw materials furnished by the tar.

Benzene, the most important of the hydrocarbons obtained from the tar, has proved a valuable fuel for motor engines. In addition to that derived from the tar, further quantities may be obtained by washing the gas with heavy oils which dissolve the benzene and yield it up again on distillation.

The importance of benzene as a fuel in lieu of petrol is very great; ample supplies of such a home product would do much to check artificial prices for petrol. It has been estimated that it would be possible to produce annually some twelve million gallons from gas-works and sixty million gallons from coke ovens, if all coal were treated in recovery plant.

Benzene is also employed for cleaning purposes (cloth, fabrics, etc.), and quantities are now converted to synthetic phenol (carbolic acid), from which picric acid (lyddite) is prepared.

Another hydrocarbon closely allied to benzene is toluene, for which there is a great present demand for conversion into trinitrotoluene (T.N.T.), the powerful high explosive. Quantities are now obtained by oil scrubbing of the gas and also synthetically from benzene.

Phenol (carbolic acid) can be extracted directly from the light oil and carbolic oils by washing with caustic soda; also the closely allied cresylic acids. All yield high explosives on nitration.

Consideration may now be given to the more economical utilisation of our coal, and the natural course will be to deal first with wastage in production. In the past coal-mining has been characterised by the little regard which has been paid to wastage of good coal, often, of course, through financial considerations.

Many of the losses in mining coal are unavoidable —for example, by reason of the small dirty coal produced—but a great deal of really good coal is often wasted because it does not pay to bring it to bank.

With the introduction of coking plants, of briquetting plants, and of sizing and washing plants, the amount of small coal wasted has been very materially reduced, and the increased price for such prepared coals has proved an important factor in the economy of coal.

Turning now to economy in use, with our present knowledge of methods of getting power from coal, the best utilisation we are likely to effect (by gasification and use directly in gas-engines) will be about equal to 20 per cent. of the available energy.

Economy in operating can be obtained by more attention to combustion, and the combination of the purchase of coal on a scientific basis with scientific control of combustion leads to very considerable economies.

In the whole scheme of coal economy it will obviously be desirable to employ the form of plant which gives the highest thermal efficiency, for by such plant the lowest fuel consumption will be attained; but many other considerations besides thermal efficiency will be taken into account. It was to gaseous fuel that the Royal Commission (1905) looked for the realisation of enormous economies in coal consumption. Since that date, however, the steam turbine has developed and, although inferior as a heat-engine to the gas-engine, has proved a more serviceable power unit for large-scale power production than the gas-producer and gas-engine. For power production and distribution as electrical energy on a large scale the turbine has practically completely supplanted the gas-producer in the opinion of engineers.

Producer-gas plants with gas-engines, however, have their proper sphere in the economy of coal, and have contributed very largely to economy. Another important point is that a class of coal totally unsuited to use for steam raising can be employed in a producer, so that good steam-raising coal is economised.

The introduction of suction gas plants has also been a great advance, because such plants have almost invariably been installed in place of moderate and small-sized steam plants, the latter being notoriously inefficient as power units.

There are two very important industrial operations where great saving is possible, even although considerable progress has been made in reducing this waste. These are the waste of heat in blast-furnace and coke-oven practice.

The available surplus power from blast-furnaces amounts to a very large figure. Approximately, for every ton of iron produced, 150,000 cub. ft. of gas of a calorific value per cubic foot of 90 to 100 B.Th.U. are obtained. After heating the blast stoves and operating the plant with gas-driven engines, a surplus of 65,000 cub. ft. may result, this being equivalent to an output of about 650 b.h.p.

The surplus gas available in coke-ovens per ton of coal carbonised is about 5000 cub. ft., and its calorific value about 550 B.Th.U. per cub. ft., so that a coke-oven plant carbonising 400 tons per day and giving the above amount of surplus gas will, with the consumption of 21 cub. ft. per b.h.p., operate a power plant with an output of 4000 b.h.p. per hour.

Surplus coke-oven gas is being utilised as a source of power for the supply of the collieries, or in connection with a "waste-heat" scheme, in admixture with producer gas for steel-making, and as supplementing the supply of coal gas in the neighbourhood.

In the field of fuel economy, great as savings would be which can be realised by individual action, they are small as compared with what might be realised by collective action throughout a district, and the extensive scheme which has been in operation on the North-East Coast for some years is an object-lesson in what can be accomplished.

The underlying principle is to have a uniform collecting and, therefore, distributing electric system. Waste heat from coke-ovens and blast-furnaces, and exhaust steam from blowing engines (through low-pressure turbines), are utilised continuously at maximum electrical output, and the supply supplemented as necessary from steam-operated turbine sets at a limited number of stations.

The area covered by the scheme is 1400 square miles; the length of the district (north to south) is seventy miles; and the present total horse-power generated, 343,000. Collieries with an output of more than twenty million tons now depend on this supply, and show a saving of about 75 per cent. in coal consumption (equal to one million tons of coal); the suburban railways are supplied with electric power for eighty miles of single track; heavy freight haulage is carried out on fifty miles of track; tramway systems are supplied with current. In addition, lighting is provided in towns with an aggregate population of 700,000. Another important feature is the development of new industries, notably electro-chemical.

There can be no question that enormous economies are possible on similar lines in the great industrial centres, because existing conditions are generally favourable. There has been a natural concentration of industries and population in the vicinities of our coalfields; the principal sources of waste heat—iron smelting, with its complement, coke manufacture—have developed naturally in the same areas. There is the large demand for power for industries, for locomotion, and for the general supply of heat and light to a large population.

London is in a special and unique position as regards such a general-power scheme; it is far removed from coal-producing districts (at least, until there has been considerable development in Kent); it has an enormous population and big demands for power, although no large individual demands which compare with the big industrial concerns in the North; and enormous demands for lighting and domestic heating.

Waste heat is not available in the London area, and current would have to be generated at large stations situated below London, necessarily on the riverside, so as to secure the advantages of sea-borne coal and ample water supply. For the most efficient scheme I feel convinced that the gas companies and future low-temperature carbonising concerns will have to supplement the directly generated current, the former being linked in by utilising surplus coke in producers and the producer-gas in gas-engines coupled with generators, the latter through their surplus gas, to be mixed with poor producer-gas (possibly the coke-gas referred to). The gas companies already have their distributing system and market for gas; the low-temperature coke will find the best market in the country at hand.

In this way three important concerns, which would handle coal as their main raw material, could be linked up through the medium of the future uniform system of electricity distribution in the metropolis to the very great advantage of the community, providing cheap electricity and smokeless fuel, and retaining coal-gas with its many advantages.