INAUGURAL ADDRESS.

By S. Z. DE FERRANTI, President.

I propose to address you on the following subjects :—

COAL CONSERVATION,
HOME GROWN FOOD, and
THE BETTER UTILISATION OF OUR LABOUR.

I believe that these problems are closely connected and are all capable in a great measure of being solved by means of an electrical treatment.

There are few subjects more important to the people of this country than the question of the rapid and ever-growing rate at which we are using up our coal supplies. Many writers have dealt with this subject, and have suggested various remedies.

It may be said that the rate at which we can use coal is a measure of our industrial activity and prosperity. This would be true, perhaps, if we were using our coal without waste, or at least with reasonable economy, but it is certainly not true of what we are at present doing.

Taking all the uses for coal into consideration, I believe that we are getting back an amount represented by useful work of one kind or another of much less than 10 per cent. of the energy in the coal. We can never, of course, hope to get anything like the full value of the energy in the coal, but, on the other hand, throwing away more than 90 per cent. of the value of our coal in the process of conversion is of the greatest possible concern to the country. Moreover, there is a further waste involved in our present methods of using coal which is only second in importance to the one I have spoken of.

We now dissipate nearly the whole of the valuable by-products contained in the coal, consisting principally of fixed nitrogen.

Besides the question of the waste of our coal by misuse, there is another cause working at an ever-increasing rate towards the exhaustion of our supplies. I refer to the immense exportation of our coal to other countries.

I will now turn to the question of our food supplies, and without going into details, which are available for every one to read and study, I would remind you that we now import the greater portion of our food because we believe it pays us better to do so.

This state of affairs is brought about by a number of complex circumstances, but is, in a measure, due to the necessary uncertainty of prices in our market under our present system, the comparatively small acreage that we have available, and to getting an insufficient return from the land that we have under cultivation.

Our only chance, however, of supplying our food requirements lies in a successful system of intensive cultivation throughout the country. This, in its turn, depends upon many things, but primarily it can be stated that it involves spending money in order to get the greater return required, and our farmers are naturally averse to spending money when the return to be obtained is so problematical. It is also attributable to the fact of intensive cultivation requiring a liberal supply of chemical fertiliser for the land, principally in the form of fixed nitrogen. This commodity, on account of the wasteful system of using our coal, is, I believe, at too high a price to make intensive cultivation attractive to the farmer.

There is a further difficulty still standing in the way, viz., the want of knowledge on the subject of intensive cultivation, but I am sure that once a sufficiently general interest was felt in the country, and a sufficient prospect of reward to workers on this subject assured, that knowledge would grow at a rapid rate and soon bring about an efficient system of using our land to the best advantage.

The third subject that I have mentioned to you is that of our wasted labour. It may be said that all labour is useful insomuch as, if it were not required it would not be used. On the other hand, we may consider the theoretical case of all labour being wasted insomuch as it is possible to conceive of a vast automatic machine which, with the direction of a single person, would fill all our possible requirements and would include in its many functions a capacity for keeping itself in repair, and extending its operations to all new wants that it had to fill. There is, however, as in most things, the middle course for which we should aim, and that is, the supply of all our reasonable wants with the least possible amount of labour.

Looking at the question more in detail, we can first consider the labour spent in and about raising and distributing the coal which we now use, and which we would save under more economical conditions. Then there is the vast army of workers who are employed in cleaning up the dirt that is produced by our present methods of using coal. If we consider what goes on in every household we shall see how large a proportion of the domestic labour is devoted to this. There are also all the people who are now employed in the process of burning coal for all the various uses to which it is put and who represent an enormous amount of labour which, under a more efficient system, could be turned to better account in the interests of the country.

It must be evident that the more efficient running of the country as a whole, the more rapidly must it add to its wealth and diminish the amount of labour which individuals have to expend in order to live at a given standard. This efficient working of the country to a large extent depends upon the proper use of its natural resources in the form of material and labour, and the saving of all waste in both of these which can possibly be brought about.

Considering the question of coal saving, by-product recovery, and labour saving, it is evident that the onlv way of obtaining material improvement under these heads is to concentrate the process of transformation of the coal and to carry out this process at the smallest reasonable number of centres.

It is in the process of transformation of coal into work in the form of heat and power that the great loss occurs, as this is always a most difficult process and requires the highest scientific and practical skill to carry out with even very moderate economy.

It has been proposed, with a view to accomplishing the above ends, to treat the coal at central stations and turn it into gas and distribute the energy in this form, but this process only goes a small way towards a solution of the problem, as under it, combustion—which is such a difficult problem—would be taking place at numerous points over the whole country, all tending to inefficiency, and the conversion of the gas into power is by no means easy, involving running machinery of the reciprocating class, requiring special and skilled attendance.

It appears that with a problem such as we are discussing it is fundamental that the energy in the coal should be converted at as few centres as possible into a form in which it is most generally applicable to all purposes without exception, and in which it is most easily applied to all our wants, and is, at the same time, in a form in which it is most difficult to waste or use improperly.

We are therefore forced to the conclusion that the only complete and final solution of the question is to be obtained by the conversion of the whole of the coal which we use for heat and power into electricity, and the recovery of its by-products at a comparatively small number of great electricity producing stations. All our wants in the way of light, power, heat, and chemical action would then be met by a supply of electricity distributed all over the country.

It must, however, be remembered that the distribution of energy in the form of electricity instead of coal can only be effectively carried out when it can be done in such a way that it is available for all the purposes for which coal is now used, and this can only be the case when the conversion is effected at such an efficiency as will cause the electric energy delivered to represent a high percentage of the energy in the coal. Failing this no scheme for conversion at the pit's mouth and delivery of energy in the form of electricity is sound. There is also another controlling factor which must be satisfied in order to make this scheme possible. Both the conversion of the coal into electricity and the distribution of the current must be effected at a low capital cost so as not to overburden the undertaking with capital charges.

Considering the various processes of conversion which are now available, or which may be invented and their possible and probable efficiency, we first come to electric generators driven by reciprocating steam engines. Their economy, expressed in the form of energy in the coal to electric energy, may be taken as a maximum of 10 to 12 per cent. This is, of course, far too low an efficiency to make any scheme such as I have already indicated possible, besides which the capital expenditure and the complication involved are far too great and the size of the units too small to be thought of for the purpose in view.

We next come to large steam turbines such as have been constructed up to the present, and see that their maximum efficiency may be put down at about 17 to 18 per cent.

Next in the list, in order of economy, comes the big gas engine fed from gas producers, with an efficiency of coal energy to electric energy of possibly 25 per cent.

In the future we have to look towards two other means of conversion—the gas-turbine-driven electric generator and the production of electricity in some more direct way from the coal, but these two means of conversion, although capable of giving the most efficient results, are so much in the distance, that they are quite beyond our present consideration.

After very careful thought on the subject I have come to the conclusion that, in order to supply electricity for all purposes it would be necessary, amongst other things, to have a conversion efficiency of not less than 25 per cent.

For the purpose of looking into this question I have taken the figures of production and consumption given in the Report of the Royal Commission on Coal, which clearly summarises the position as it stood a few years ago, and as the increase taking place is fairly regular these figures have been taken throughout. According to this report 167 million tons of coal were being used in the country in 1903. Of this amount 2 million tons went to coasting steamers and 15 million tons were used by the gas companies. In order to simplify matters, and make the figures clear, I have left out of consideration the coal used on these two items, and taken the balance —viz., 150 million tons—as the annual coal consumption of the country. If now, instead of using this coal for doing work as at present, we were to convert it into electricity, we should use, instead of 150 million tons, 60 million tons of coal a year. This coal, turned into electricity, would produce 131,400 million Board of Trade units, and the electricity so produced would, after allowing for losses of transmission and conversion into work of different kinds, be sufficient to supply the whole of our requirements now being satisfied by the use of the 150 million tons of coal which we now burn. To form an idea of the magnitude of the proposal it is well to compare it with electrical supply as we know it to-day.

At present of all the coal we burn in the country only 1 per cent. is used by the public electric supply works of which returns are published, and it is therefore evident that electricity has up till now hardly commenced to displace direct-used coal.

In the conversion of coal into electricity one of the most important considerations is the load factor at which the converting and distributing plant effects the operation.

Electricity used for lighting, cooking, power, and traction must be supplied as and when required. On the other hand, domestic heating will be done largely through the medium of heat storage, and is therefore a controllable form of demand. Metallurgical and chemical processes, which depend for their success upon a very cheap supply of current, will have to be so adapted and modified that they can take current intermittently and so fill up the load curve, thus enabling the current which they require to be produced with the least capital expenditure and at the same time greatly assisting the good conversion efficiency of the whole supply. I believe that under the circumstances a load factor of 60 per cent. would be obtained. At first sight it seems unreasonable to expect such a load factor, but it must be remembered that our ideas are based on the present electric supply, which only uses some 1 per cent. of the coal now consumed in the country.

At present, as is quite natural, electricity is used for what coal does least satisfactorily direct, and it is misleading to compare the load factors so obtained with those which will be got when electricity replaces coal entirely.

Considering now the means to be adopted for converting the coal into electricity, and the efficiency at which this can be done, we find that in gas-engine-driven alternators we have a system theoretically capable of returning 25 per cent. of the energy in the coal in the form of electricity, and from this point of view they would meet our requirements.

The gas engine, however, as a converter of energy on the scale required suffers from the fact that the units are too small and the cost of the complete installation is too high. These difficulties appear to defer the realisation of an all-electric scheme until electricity is generated by some gas turbine of the future, or direct from coal by chemical action.

There is, however, an intermediate process of conversion which will, I believe, give the necessary efficiency without undue complication or expense. The steam-gas turbine in which steam is used in the state of a gas at a high temperature throughout the process of conversion into work, gives theoretically a high efficiency at workable temperatures, and I believe will, in course of time, supply the necessary means of conversion for effectively turning our coal into electricity. I have therefore considered the case on these lines.

In order to produce the supply of 131,400 million Board of Trade units at a 60 per cent. load factor, machinery of the normal capacity of 25 million kilowatts would have to be installed.

For the purpose of estimation it may be considered that this capacity would be divided up into 100 stations of the capacity of a quarter of a million kilowatts. Each of these stations would contain

10 generators of 25,000-k.w. capacity. These stations would be spread about the country to supply the demand in each part roughly proportional to the coal now consumed.

The positions of the actual generating stations would be largely controlled by the facilities for obtaining coal and water for condensing. In many cases they would be close to the colliery districts, and the current would be transmitted tc the points of demand.

In other cases, where a considerable demand was concentrated at a distance from the sources of coal supply, and where the coal could be cheaply carried—especially by water—stations would be installed and would supply electricity to meet the surrounding demand. In all cases, however, whether far from, or near to the coal production, the coal would be delivered in very large quantities to only a few points of consumption, and would thus reduce the labour and cost of transmission and handling to the lowest figure.

Many works taking a large quantity of electricity for metallurgical and chemical purposes at a very low price would be built adjoining the generating stations, and other existing works would be at such short distances that the capital costs for distribution of the electricity which they used would be very small.

Estimating on the basis of the typical generating station considered and multiplying by the number of stations, I have put down the capital cost of generating works at £7 per kilowatt, which, for the total kilowatts required, gives an expenditure of 175 millions sterling. The cost involved in the distribution system on such a scale is difficult to estimate. The conditions of demand in relation to the position of the supply stations would, however, be favourable, as a great deal of the energy required would be transmitted only short distances, and units of demand would be large. Under the circumstances, I believe that £13 per kilowatt would be amply sufficient, and a sum of 325 millions sterling would thus cover the cost of the distribution system.

The total cost of the scheme, including all expenses up to the point of delivering the electric supply to the consumer, would thus be 500 millions sterling. This, of course, is a very large figure, but, considered in relation to other industries and the results to be accomplished, cannot be considered excessive.

It has been estimated that the capital now invested in this country in electrical undertakings amounts to some 400 millions sterling. Last year the Electric Supply Business had invested in it some 58 millions sterling. The proposed scheme would therefore absorb from eight to nine times the amount of capitital now invested in the portion of electric supply undertakings for which figures are available. The units generated upon the all-electric method of working would, however, be some 150 times as great as those generated by the above undertakings, and the cost of production and sale price of current would, of course, be very much lower than at present.

The cost of producing the electricity required under the scheme may now be considered. Capital costs taken at 8½ per cent. upon the money invested, form by far the most serious item, and amount to 0·0776d. per unit, or a total of £42,500,000 per annum. The works costs would, I believe, not exceed 0·036d., bringing up the total costs, including interest and all other charges, to 0·1145d. per unit, or 62 millions sterling per annum.

In arriving at the above figures for the costs of generation 60 million tons has been taken as the annual coal consumption, and this has been charged at an average price of 10s. per ton, thus amounting to 30 millions sterling. On the other hand, it has been assumed that with improved processes of conversion, 1 ton of coal will yield fixed nitrogen equivalent to 1 cwt. of sulphate of ammonia. The present price of this commodity is well over £12 a ton, but considering the large scale of production and the necessity of supplying it at a low price to make its use general for agricultural purposes, I have reckoned the fixed nitrogen as of a value of only £8 per ton of sulphate of ammonia or, on the 3 million tons to be produced, of 24 million pounds sterling. This reduces the cost of the coal to 6 millions sterling, which largely accounts for the low works costs.

The cost of chemicals required to make the fixed nitrogen available together with the necessary labour involved in the process, would be met by the sale of the other coal by-products—principally consisting of tar and oils.

It is, of course, well known that firing by means of gas compares unfavourably with using the coal direct. It is also generally found that a good return of fixed nitrogen in the form of ammonia is only obtained from the coal at a sacrifice of thermal efficiency, and also involves a much smaller yield of the other by-products which can be extracted from the coal, but now that the importance of these matters is realised a great deal of work is being done to improve the processes, and eventually it will undoubtedly be possible to obtain the high return that I have spoken of without sacrifice in other directions.

Following upon the costs of electric generation already discussed, I have assumed, for the purpose of comparison, that the average price at which current would be supplied throughout the country would be ⅛d. per Board of Trade unit. The charges would not be uniform, but would be graded according to the position and nature of the load supplied.

It is interesting for a moment to consider the effect of such a supply of electricity upon its present and future uses.

Taking lighting to begin with, which was the first application for which a supply of electricity was generally given, it will be clear, considering the strong position which electric lighting now holds even with current at an average price of 2d. per Board of Trade unit, that when it is obtained from current at the much lower prices that would rule under the all-electric scheme no other form of light would have a chance in competing with it.

Notwithstanding present high prices, a good deal of electric cooking and heating is already being done, and although it would appear to be too expensive for general application, still the very good results obtained and the large amount of labour saved is already sufficient to justify its use to-day.

When electric heating and cooking are carried on with current at the very low figures at which it would be possible to sell for these purposes, it would only be a matter of time for all heating and cooking to be done by means of electricity.

Regarding the supply of power, electricity is now admittedly the most convenient form of power for all purposes, and this, again, notwithstanding the costs involved on the comparatively small scale on which we now produce. The overwhelming advantages of electric power at a price at which it would be supplied on the all-electric scheme would clearly ensure its use for all power purposes.

The case with regard to electric tramways and light railways is well known, and any reduction in the costs of running due to cheaper current would, of course, act greatly in favour of these undertakings, and would help to extend their usefulness. Light railways, which, for various causes, have made such poor progress, if sensibly dealt with, would greatly benefit by finding a cheap supply of energy available in all parts of the country.

The electrification of main-line railways has not yet progressed very far, as it is hard to make out a sufficiently strong case to warrant the large expenditure necessary for electrification; but there is little doubt that growing traffic, which necessitates additional works, will be best met by electrification, which will enable a greater return to be obtained from existing lines and works. The electrification of our railways would be greatly assisted and made a more profitable investment if a supply of current at such a figure as we are now considering were available for their working.

The manufacture of pig iron is, no doubt, quite the most economical use of coal that we now have, but recent work with electric smelting furnaces has shown that it is only necessary to have electric current at a low enough price and for sufficient experience to be obtained to make it more economical to smelt iron electrically than by present methods, and using only sufficient coke to provide the carbon for the purpose of reduction.

It may be taken, from the experiments already made, that when worked on a sufficient scale a quarter of a ton of coke would be required per ton of iron produced, and that 4 tons of iron would be obtained per kilowatt-year. This would mean that about 0·42 ton of coal would have to be converted into coke and used per ton of iron, together with about 2,200 Board of Trade units, which, at $\frac{1}{12}$d., would come to 15s. 3d. per ton of iron. As the electric furnaces would no doubt closely adjoin the generating station the price named for current would be a very good one. We should thus have a cost for coke and electricity of about 19s. 6d. per ton of iron produced.

According to the recent Report of the Royal Commission on Coal, pig iron, on the average, now requires about 2 tons of coal per ton of iron produced, and taking this at the same price as coal has been taken for the purpose of electric generation, viz., 10s., this would give 20s. as the cost of fuel per ton of iron produced. It is, however, probable that the production of pig iron electrically with current supplied to the works would involve less plant and a less upkeep of plant than at present: also a good deal less labour would be required. Improvements in the process brought about as the result of experience would, no doubt, further reduce the costs, and would result, in all probability, in a better article at a lower price.

We at present produce about 10 million tons of pig iron. This would therefore require 2½ million kilowatts of plant run continuously and producing 22,000 million Board of Trade units annually. In order to get current for this purpose at the lowest price, it would in all probability be found desirable to insulate the furnaces to avoid heat loss, and for the same reason to have individual furnaces of a very large capacity. It would then be possible to work intermittently and yet with economy, and so use the current taken by the furnaces to fill up the load curve, thus adding to the economy of conversion and reducing the capital expenditure involved in electric plant.

Steel-making electrically is already in extensive use, and even with present facilities for generating the current which the process requires is beginning to make considerable headway. All steel would, of course, be produced electrically as soon as sufficient experience had been gained regarding details and a supply of very cheap current was available.

Foundry work in both iron and steel would be most conveniently carried out by means of electric melting. It is already known that the electric furnace gives the best results obtainable for steel castings.

The heating of steel for rolling, forging, and annealing will be most efficiently carried out electrically as soon as the cheap supply warrants experimenting in this direction. In fact, all furnace work for which coal or gas are now used could, I am convinced, be more satisfactorily done electrically when an abundant and cheap supply is available.

We now use aluminium for a number of purposes, notwithstanding our want of knowledge as to the best ways of working it. When our experience with aluminium in any way approaches what we now know about the working of steel, it is certain that vast quantities of this material will be used throughout the world. The manufacture of aluminium is another of the processes which will be greatly facilitated by a cheap supply of electricity. In fact, it may be said that aluminium can only be produced economically at present in water-power countries, but as an intermittent supply of electricity could be given under the proposed scheme at a lower price than it is being obtained from water powers, we should be in a better position than the water-power countries to manufacture this metal.

With cheap electricity available, electro-chemical processes must grow and multiply to an enormous extent, and not only should we produce for ourselves all the chemicals which are now produced electrically abroad, but everything that can be produced electro-chemically would then be made in this country.

There is a further application of the electric current which, so soon as the price was low enough, would, no doubt, largely come into use. This is the intensive growing of fruit and vegetables under glass. It is known that considerably more forcing in the way of heat can be advantageously applied where light is also furnished artificially, and it is therefore probable that, with electricity everywhere available at a low price, an immense amount of intensive cultivation under glass with the heat supplied by means of the electric arc would be undertaken, as in supplying heat by this means light would also be supplied, which would have the effect of enabling the growth to benefit fully by the artificial heat.

Summarising the whole position, it may safely be said that, wherever coal, gas, or power are now used, everything for which they are used will be better done when electricity is the medium of application.

Hardly less in importance in the all-electric scheme is the question of the by-products which become available by the proper use of our coal. These consist principally of fixed nitrogen, together with tar and oils.

Fixed nitrogen in the forms of sulphate of ammonia, nitrate of soda, and nitrate of lime are most valuable fertilisers, and enable land continually to produce the same crops with a greatly increased yield per acre. Much has been done in finding out how best to utilise these artificial fertilisers, but no doubt a great deal more will be done in this direction, and fertilisers will be prepared, with fixed nitrogen as their principal constituent, which best suit the particular soils and crops that it is desired to deal with.

According to last year's Board of Trade returns we now grow about 23 per cent. of the total wheat that we use and import 77 per cent. Of the barley used we grow 59 per cent. and import 41 per cent., and of the oats used 78 per cent. is home grown and 22 per cent. imported. Last year we devoted 7¾ million acres to the cultivation of these crops.

Much is being done to improve the yield of corn crops, and it is probable that with scientific treatment in the production of the seed, in the sterilisation of the ground, and in the application of fertiliser, we may look at no distant date to an increased yield of 50 per cent. in these crops upon what is now being produced per acre. The most vital feature, however, in bringing this about, once we have acquired sufficient knowledge, is an ample supply of fixed nitrogen to use as fertiliser, and it is when considered from this point of view that a scheme which supplies this from our coal as the result of saving present waste is most important.

With the increased yields which we have mentioned we could produce corn crops sufficient to supply the whole of our requirements upon 11 million acres. This would represent 23½ per cent. of our present cultivated area, and would only be an addition of 3⅓ million acres to the land now used for the purpose of growing these same crops. The value of these additional crops would be about 58 millions sterling, based upon the prices which we paid last year, and to this would have to be added the value of the straw and the other wheat by-products, which would go a long way towards providing the food for growing the additional meat which we require to supply our demand at home.

In order to fertilise the land, we should have available, under the all-electric scheme, 3 million tons, or its nitrogen equivalent, of sulphate of ammonia. This, if used over the whole of the 46¾ million acres now under cultivation, would give 143 lbs. per acre, but, of course, the fertiliser would be distributed according to the nature of the land and the crops being grown. It is probable that under these circumstances the increased yield of the land now cultivated would not only give us all the grain that we should require for food, but also all the foodstuffs, partly as by-product from the grain and partly grown, that would be required for raising the cattle, sheep, and other animals necessary to supply the whole of our wants.

It is now beginning to be understood that intensive farming of the land also involves intensive cattle raising, and that it is very advantageous greatly to reduce the amount of grass land and instead to grow crops intensively cultivated, as in this way a given amount of land can be made to produce a much larger yield.

Sulphate of ammonia is a particularly good fertiliser for the purpose of growing sugar beet, and here again it is probable that the availability of large quantities of this fertiliser at a very much lower price than at present prevails would enable us to produce the whole of our sugar at home, especially as the by-product obtained in the form of crushings from the beet is a very valuable food for cattle raising, and also as the crop is a very suitable one for growing alternately with wheat.

If it was found that a larger amount of fertiliser than the 3 million tons of sulphate of ammonia, which would be the principal by-product from the 60 million tons of coal turned into electricity, could be advantageously used, this would be very economically produced from the electrical station by the oxidation of atmospheric nitrogen, giving a valuable fertiliser in the form of nitrate of lime. This could be made intermittently by means of current filling up the load curve and would not necessitate the expenditure of any more money on plant for generation or transmission of the current. It would, however, require the burning of additional coal, and this in itself would add to the sulphate of ammonia available.

The output of the 25 million killowatts of plant installed has been reckoned upon a 60 per cent. load factor, but it is quite possible that the load curve could be still further filled up by an additional 20 per cent. for any purposes such as those just stated. In this way it would be possible to burn an additional 20 million tons of coal annually, producing a million tons of sulphate of ammonia and other by-products, and 43,800 million additional units, which could be sold at a considerable profit at $\frac{1}{20}$d. per unit, as the cost would not exceed $\frac{1}{50}$d. per unit.

A certain proportion of this extra supply of current could be used to fix nitrogen in addition to that obtained direct from the coal, should this latter supply be insufficient for the country's wants, and the balance of the current used for electro-chemical or other requirements which could take power intermittently.

In this connection it must be remembered that an intermittent or controlled make-up load may be intermittent to the extent of 80 or 90 per cent. of the load, a certain amount of current being always kept on to make up for heat losses in furnaces or to prevent reversal in electro-chemical work.

If the whole of the additional output could be taken up the effect of the increase of revenue, together with the difference on the original figures of selling the first 60 per cent. at an average of $\frac{7}{8}$d. instead of at the lower figure of 0·1145 of a penny already mentioned, would enable $10\frac{3}{4}$ per cent. to be allowed on the capital instead of $8\frac{1}{2}$ per cent. already provided for.

It is assumed by many people that the climate of this country is largely unsuitable for the purpose of growing food, and for this reason it is thought that we can never grow the food which we require. This is largely a misconception, as crops both large in quantity and of good quality can be produced in this country. Nevertheless, it would be a desirable thing if, instead of the dark weather that we now often experience owing to cloud obstruction, we could have continuous sunshine at certain times of the year. The amount of sunshine would, no doubt, be largely increased by the abolition of all smoke in the air, as not only does the smoke itself obscure the sun but also it seems to have the effect of assisting the formation of cloud, which greatly diminishes the light and heat which we receive.

At present it is considered quite right and reasonable to canalise rivers and make great works for adding to the fertility of countries by means of irrigation, but I believe that in the future the time will come when it will be thought no more wonderful largely to control our weather than it is now thought wonderful to control the water after it has fallen on the land. I think that it will be possible to acquire knowledge which will enable us largely to control by electrical means the sunshine which reaches us, and, in a climate which usually has ample moisture in the atmosphere, to produce rainfall when and where we require it.

It seems to me that it may be possible, when we know a great deal more about electricity than we do to-day, to set up an electrical defence along our coasts by which we could cause the moisture in the clouds to fall in the form of rain, and so prevent these clouds drifting over the country between ourselves and the sun which they now blot out. It also seems to me that it will be possible, when more water on the country is required, to cause the falling of rain from the clouds passing over the highest part of the country and so produce an abundance of water which, properly used, would greatly add to the fertility of the country.

Of course, it may seem that these are only mad visions of the future, but I think we can hardly consider these results more improbable than any one would have considered wireless telegraphy or flight in heavier than air machines fifty years ago. My excuse for mentioning these matters here is that they might constitute another great use of electricity, and their useful consummation would certainly be facilitated by an abundant supply of electrical energy.

There would be further by-products from the coal in the form of tar and light oils. The effect of their abundant production and sale at a low price would be most important to the country, as the large quantity of tar produced would enable us to make good roads, which we much need, and which would have the lowest cost of upkeep, and the light oils would, when carburettors have been further developed, go a long way towards supplying the fuel for our motor-cars and other motor vehicles which we now have to import from abroad.

As there must be an enormous development in the way of motor traction these two by-products become most important. The necessity for labour-saving appliances used in agriculture must greatly add to the number of motors which cannot, according to present knowledge, be replaced by electricity, and these, no doubt, would be made to burn the heavier oils which would be produced as part of the coal by-products.

Considering the general effect of the all-electric scheme, in which, with but small exception, the whole of the coal used is turned into electricity, the first important effect would be the saving of some 80 to 90 million tons of coal a year. As we should produce the whole of our food requirements, we should not have to export our capital in the form of coal to help pay our food bill. In this way, by making these two savings, we could prolong the useful life of our coal measures two and a half times, and still have 20 million tons of coal a year available for the use of our steamships over and above the coal required in the country.

The saving of labour now employed in raising the vast amount of coal which we now waste or send abroad, and also the labour employed in transporting this coal and using it for all the various purposes for which it is now required, together with the labour employed in cleaning up and getting rid of the effects of burning coal according to our present methods, would all be available for additional manufacturing of the articles now imported and for use on the land.

The saving of so much wasted labour and material would greatly add to the prosperity of the country and so enable us to support a larger population living under more healthy and comfortable conditions than at present.

Cheap electricity would greatly stimulate all manufacturing operations, which would, in turn, enable labour to be much better remunerated than at present, and to enjoy a much higher standard of comfort. The higher value of labour would in its turn stimulate inventiveness and the production of all sorts of labour-saving appliances which, with cheap electricity, would enable us to produce in the future under suitable market conditions at cheaper rates than are now possible, notwithstanding the better return that labour would obtain.

Great hardships are always produced where any great industrial change is made, but the more efficiently we can carry on the work of the country the more margin must there be for the great majority of the people : so that any change which decreases the amount of labour required must eventually give the people greater comfort and less arduous work. It is hardly necessary to point out how much better the position of the country would be if we were producing the whole, or nearly the whole, of our requirements, as in this case we should be far less liable to be adversely affected by any external causes or by the occurrence of any great war.

At present, although the using of our coal may mean commercial activity it certainly means the desolation of the country in parts where it is largely used. Instead of this harm being done to the country by our coal, we should fertilise the lands by its means and might even, as I have indicated, use it in the future to increase our sunshine.

Of course there are many things which at present stand in the way of realising such a scheme as I have outlined. There are many technical details which nothing but an immense amount of work can solve satisfactorily. There are also political and legislative difficulties standing in the way, but these, when the time arrived, would have to be got rid of rather than allow them to handicap the advance of the country. The more, however, that I have considered these ideas in detail, the more certain am I of the fundamental soundness underlying them and that it is only a matter of time before such a scheme is carried out in its entirety.

What interests us most, perhaps, is the question of how long it is likely to be before the all-electric idea becomes possible. At present there is so much required to be done to make it workable in all its details that it seems as though its realisation would be long deferred. It must, however, be remembered that knowledge is continually being acquired which brings us nearer to its realisation, and that things engineering, and especially in electrical engineering, now move very rapidly. It may therefore come to pass that the all-electric idea, with its far-reaching changes and great benefits, will become an accomplished fact in the near future.

Mr. R. K. GRAY : Ladies and Gentlemen,—It is my pleasure to lay before you the following resolution : "That the best thanks of the Institution be accorded to Mr. S. Z. de Ferranti for his interesting and instructive Presidential Address, and that, with his permission, the Address be printed in the *Journal of the Proceedings* of the Institution." Mr. Gray

Mr. Gray. I am sure we have all listened to our President's Address with a great deal of interest. The occupancy of the chair on such an occasion as the present, carries with it a great advantage in that one can speak quite freely and without fear of contradiction, and this freedom enables the speaker to irritate the minds of his hearers in such a way that some real progress is likely to result. Our President has taken full advantage of this immunity, and has given us all a great deal to think about. I am sure I am expressing the feeling of the meeting in thanking Mr. Ferranti for the pains he must have taken in the preparation of his valuable address, and for the food for reflection he has laid before us. We all sincerely hope that he may live long enough to see realised some of the advantages that may come from our action provoked by the address we have just heard.

When I have been abroad I have met people who have asked me, "Is Mr. Ferranti still alive." In spite of our President's actual years and his appearance we cannot wonder at people asking this question as so many years have elapsed since his name came first into public view.

Should any doubters exist their doubts will be dispelled when our President's Address reaches them, as it distinctly shows that Mr. Ferranti is very much alive.

Dr. Glazebrook. Dr. R. T. GLAZEBROOK : Ladies and Gentlemen,—I rise with great pleasure to second the motion that Mr. Gray has put before you. Before we heard the President's Address we were all ready to give him a warm welcome. We were ready to welcome him as a pioneer whose work has done so much for electrical engineering through those many years in which he has been actively engaged in it. We knew that from him we should have a brilliant and original address, and we have learnt to-night, I think, something of the value of the imagination in science. It is good to give rein from time to time to the imagination even in our daily prosaic work. Mr. Ferranti has been a prophet in years before, a prophet speaking sometimes, it may be, to deaf ears. It is a pleasure and a privilege to the Institution to honour their prophet in their country. All of us cannot hope to live to those happy days when electricity will be sold at the rate of $\frac{1}{8}$d. per unit, but those of us who do, and those among our children who are alive when those days come, will look back to this evening as an historic occasion ; and those of us who are still alive will be glad that we have taken, at any rate, some part in it by listening to the address.

I have now great pleasure in putting to you the resolution moved by Mr. Gray : "That the best thanks of the Institution be accorded to Mr. S. Z. de Ferranti for his interesting and instructive Presidential Address, and that, with his permission, the Address be printed in the *Journal of the Proceedings* of the Institution."

The resolution was then put and carried by acclamation.

The President. The PRESIDENT : Mr. Gray, Dr. Glazebrook, Ladies and Gentlemen, —I am most deeply grateful for the very kind way in which you have proposed this vote of thanks, and for what I feel are the very happy