in certain forms. In every case the correlation coefficient was high.

Miss Katharine L. Johnson read an interesting paper on the results of the application of Binet's tests to 200 school-girls in Sheffield. In her experience one of the chief difficulties was the personal equation of the experimenter. It is impossible to maintain the same tone and expression throughout, and children are very susceptible to suggestion. It is also difficult, sometimes, to estimate the results. She had found cases in which girls failed in the tests for their own age or for the age preceding, and yet satisfied the tests for a superior age.

Dr. E. Neumann's paper was summarised by Dr. Lucy Hoesch Ernst. He cast a doubt upon the possibility of determining a normal standard of intelligence for each year of school life which would be of general validity because of the difficulty of excluding acquired knowledge.

Dr. C. S. Myers entered a caveat against the collection of masses of psychological data by untrained observers. He was of opinion that the personal equation of the observer could not be got rid of, and that therefore comparison of results was only possible within very narrow limits. Racial differences in correlation are bound to vitiate the results of the examination of a sample of a heterogeneous people. But the main source of error lies in the neglect of the introspective element. A test of mental fatigue may in different subjects involve the play of such complicating factors as boredom, duty, ambition. It is only by individual introspection that we can determine exactly what factors an experiment involves. The result derived from the wholesale collections made by untrained observers can be nothing but a blur in the psychological aspect, though a sort of standard of productiveness may be obtained from them whereby we can measure the individual.

Dr. W. H. R. Rivers summed up the long discussion. In his opinion the work done was well worth doing, and marked a great advance regarded from the point of view of the scientific psychologist. But an enormous amount would still have to be done before the results could be applied practically in education. The work, so far, had been work with mass results, whereas the teacher wanted to test the individual. In spite of what had been said of the need for training in the investigators, it was all to the good that teachers were beginning to take up psycho-pedagogy.

On the third day of the meeting there was a series of papers on practical work in schools. The Board of Education's recent Memorandum on Manual Instruction came in for a good deal of praise. Sir Philip Magnus, as an old fighter in the cause of handicraft, urged that we should not fold our hands until the Board's four principles were everywhere observed, that handwork should be taught to all intending teachers, and that there should be a continuous course of it in every school taken by the ordinary teachers of the school. The president of the association spoke of the value of handwork as fostering self-help and initiative. Mr. J. G. Legge suggested the establishment of a type of school for boys from twelve to fourteen in which half the curriculum should be given to constructive work, and half the day should be spent in the workshop. Such a school would lead directly to technical training as the next stage in the education of the pupils. Mr. James Tipping described the vacation courses of the Educational Handwork Association, in which many teachers have acquired the manipulative skill, and at the same time the pedagogical knowledge, needed by teachers of handicraft; and Dr. G. H. Woollatt outlined a hundred-hour course for teachers in the making of scientific apparatus. Miss Cleghorn, in closing the discussion, warned the audience that enthusiasm in the teacher was a *sine qua non*, and hinted, at the same time, that it was difficult to be enthusiastic over the introduction of more subjects into the too short school life of the ordinary child.

Mr. Blair's paper on the relations of science with commerce and industry has already appeared in NATURE (September 15). The subject is usually treated on both sides in a spirit of vague vituperation which profits nothing. Mr. Blair's skilful marshalling of a mass of evidence from university graduates, professors, business men, and manufacturers all the world over will be of service to combatants on both sides who desire composition and not strife. In the short discussion which followed Principal E. H. Griffiths advocated bringing home to the lay mind the value of such work as Faraday's and Lister's. We should then hear less of the disinclination to believe in the application of science to business life and industry. He also advised scientific men to leave the language of the laboratory behind them when they came into the market-place, recalling Sir George Reid's words in the tests of intelligence discussion:—"It will be a grand thing when our men of science really do know everything they talk about, because when they do they will be able to tell us what it all means in plain English."

Dr. Beilby thought that things were improving; the great need was more cooperation between the two parties. The difficulty was to get the scientific man and the men of the markets together. In joint committees of professors and business men each side educated the other.

Sir William White also thought that there was no reason for alarm. We did not compare so badly with other countries. True, our rivals were better organised, but then organisation may paralyse effort. The young trained graduate of the technical college would not straightway apply his knowledge in industry; he had not the knowledge of practical business conditions. Such men should go through post-graduate courses, if possible, in works' laboratories. We must be content to train many mediocrities in order to catch the man of brilliant ability, and fortunately it takes all sorts to make the worlds of commerce and of industry.

Dr. Stead said that in the steel industry the value of research was recognised. The manufacturers had reached the point of wanting a little too much from research, and in too short a time.

Dr. H. E. Armstrong also advocated a two or three years' course in a work's laboratory for the technical-school graduate, and quoted the example of Sir Lothian Bell. Our organisation was at fault; when that defect was remedied the nation would soon regain its former commanding position in manufacture and commerce.

On the last day of the meeting an interesting series of papers was read on outdoor studies in schools of normal type. Prof. Mark R. Wright described the summer camp of the Durham Training College, Mr. G. G. Lewis showed what could be done by means of school journeys for London elementary-school children, and Mr. J. E. Feasey explained how much the interest and practicability of ordinary school work could be heightened by adapting it to the conditions of the open air.

In the afternoon there was a lively, though inconclusive, debate on voice production, in which Dr. Gray, Prof. Wesley Mills, Dr. Hulbert, Mr. W. H. Griffiths, Miss Ormay, Dr. Chichele Nourse, Prof. Silvanus Thompson, and others took part.

THE PRODUCTION AND USE OF ELECTRIC POWER.[1]

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 con-

1 From the Inaugural Address delivered at the Institution of Electrical Engineers on November 10 by Mr. S. Z. de Ferranti.

tained in the coal, consisting principally of fixed nitrogen.

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 the view of 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 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 being 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.

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 $7\frac{3}{4}$ 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 $23\frac{1}{2}$ per cent. of our present cultivated area, and would only be an addition of $3\frac{1}{3}$ 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 $46\frac{3}{4}$ million acres now under cultivation, would give 143 lb. 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 in 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 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.

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 anyone 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.

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.

MATAVANU: A NEW VOLCANO IN SAVAII (GERMAN SAMOA).[1]

THOUGH not the seat of government, Savaii is the largest of the Samoan Islands in the Central Pacific Ocean. It has a backbone of volcanic mountains, some of which rise to a height of more than 4000 feet; most of them are extinct or dormant, but there have been several small eruptions within the last 200 years, and one as lately as 1902.

The volcano of Matavanu was formed in 1905 to the north of the main ridge, and near the centre of the island. The early part of the eruption was characterised by explosions, and the ejecta were mainly solid, but later on

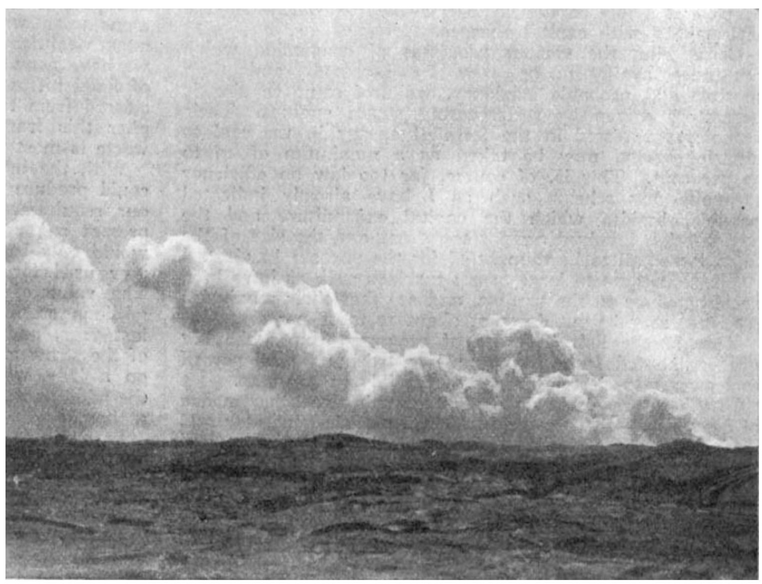

Photo.] [*T. Anderson.*

FIG. 1.—Steam Clouds from Lava falling into the Sea.

[1] Abstract of a Discourse delivered at the Royal Institution on Friday, April 29, by Dr. Tempest Anderson.