

NEWCASTLE LOCAL SECTION: CHAIRMAN'S ADDRESS.

By C. VERNIER, Member.

(Address delivered 20th October, 1913.)

ABSTRACT.

Previous to the year 1900, public electricity supplies in this country were, generally speaking, chiefly utilized for lighting. As the result of an investigation in 1898 a Joint Committee of the House of Lords and the House of Commons made certain recommendations, which resulted two years later in the granting of statutory powers to several undertakings formed for the purpose of supplying electrical energy over very large districts, covering in many cases some hundreds of square miles.

The advantages which have been claimed for these undertakings, and which are no longer open to question, may be briefly summarized as follows:—

- (1) The low capital cost per kilowatt of generating stations and the increased economy in running charges obtained by the use of very large generating units.
- (2) The development of high load and diversity factors, resulting from the varied uses which are made of the electrical energy supplied.
- (3) Low fuel costs obtained by the favourable location of generating stations and the opportunities afforded for the utilization of waste heat and other forms of waste fuel.

The important influence of low capital cost upon the cost of producing electrical energy was clearly brought out in a paper contributed to this Institution by Messrs. Merz and McLellan in 1904.* Since that time much closer attention has been given generally to the reduction of the capital cost per kilowatt of power stations, and in view of the steadily increasing price of coal it is a matter which must continue to receive great attention. Of even greater importance is the development of a high load factor and high diversity factor, both of which effect a reduction of the capital charges per unit by enabling the same plant capacity to deal with a greater annual output. The maximum economy in coal consumption can only be attained by the use of large generating sets, which further lend themselves to the lowest capital cost of installation, while on the other hand where fuel is cheaply obtained, as for instance in the case of waste heat or gas, the installation of smaller units at a higher capital cost per kilowatt may be quite justified. In general, the higher the price of fuel, or the poorer the load factor, the less can a high capital cost be defended on economical grounds. It may also be stated that in a large scheme the cheaper the fuel the more desirable it is to run the plant at a high load factor; therefore, any stations operating with cheap fuel, such as cheap coal, waste heat, or water power, must be run as nearly as possible continuously at 100 per cent load factor, the ordinary coal-fired stations dealing only with the fluctua-

tions of load. This is where the producer of waste heat finds it to his advantage to co-operate with a power company. Without this co-operation it is scarcely possible for a power station installed by such a producer to utilize the whole of the waste heat available at all times of the day and night, or in other words, to run the station as far as fuel permits on a 100 per cent load factor, and thus to obtain, as the power company can do, the best possible results.

If we now examine the conditions under which electrical energy is produced in this country, it is clear that with a few exceptions we are very far from according with the conditions that I have described as essential to a low cost of production. The multiplicity of small generating stations, some 40 per cent of which are of a capacity under 1,000 kw., supplying small districts, inevitably results in high capital charges, poor load factors, and high fuel and running costs. We, who are familiar with the extraordinary developments that have taken place in the production and utilization of electricity on the North-East Coast during the past 10 or 12 years, will be under no misapprehension as to the disadvantage under which the greater part of the country continues to be placed by this subdivision of the means of production and distribution.

When we note that the use of electricity from public-supply sources in that portion of the North-East Coast served by the power companies has increased by over 3,200 per cent within the past 10 years,* and that as the result of a cheap and abundant supply of electrical energy new industries are springing up in our midst, it is surely a matter for regret that similar rapid progress has not taken place to the same extent elsewhere.

Dr. Ferranti, in his inspiring address to this Institution three years ago,† set before us an ideal of what electricity supply should be, and it is perhaps pertinent to ask ourselves what we in this country are doing towards the realization of that ideal. Do we not see each year existing generating stations of small and moderate size being extended? Generating stations which in many cases are quite unfitted by their unfavourable situation to achieve the economical production of electrical energy. Then what of our load factors? How very few (less than 3 per cent) of our electrical undertakings of to-day can exceed even a 25 per cent load factor. Again, how many of our undertakings can profitably avail themselves of the utilization of such waste heat as may exist in their neighbourhood? Although in this district we certainly have a large share, yet we have no monopoly of waste heat and waste gases from coke ovens and blast

* In that portion of the North-East Coast not served by the power companies, which includes many of the large towns, the corresponding increase is under 450 per cent, which is also about the average for the whole country for the same period.

† *Journal I.E.E.*, vol. 46, p. 6, 1911.

* *Journal I.E.E.*, vol. 33 p. 696, 1904.

furnaces; in fact, the waste heat from these sources in existence in this country would if fully utilized be more than sufficient to operate the whole of our existing public electric supply stations, with a combined maximum load last year of between 700,000 kw. and 800,000 kw.

The first step towards the realization of Dr. Ferranti's ideal must inevitably be in the direction of the centralization of all coal-fired generating plants into large power stations supplying in bulk over very large districts, so as to obtain the benefit of large outputs and increased load and diversity factors. These stations will have as far as possible to be interconnected together, while all available sources of waste fuel must be fully utilized. What, then, is the chief obstacle to the centralization of our electric power supply? Is it not largely the opposition which is almost invariably offered by municipal authorities, and particularly by the more important of them, to the exercise of private enterprise within their borders? It will not be easily forgotten how strenuously the Power Bills were opposed by the municipal authorities, with the result that in most cases the larger towns and industrial centres were entirely excluded from the area of supply, while the supply in bulk within the area of any existing undertakings is usually made subject to their consent. To this fact, coupled to the aversion of many of our local authorities to enter into contractual relations with public companies for bulk supplies, must be attributed the slow progress which many of the power schemes have achieved.

Of course it may be argued that the centralization of power supply is not of necessity a matter to be undertaken by private enterprise, in fact the Electric Lighting Act of 1909 affords facilities for the combination of a number of local authorities, but the jealousy of control between neighbouring authorities appears to be an even greater obstacle than those previously mentioned, and, so far as I am aware, there is but one solitary instance of such a joint scheme between municipal undertakings in the history of electricity supply in this country, viz. that of the Stalybridge, Hyde, Mossley and Dukinfield Joint Board, which was formed as long ago as 1901. Be it further noted that while the Electric Lighting Acts afford to local authorities the right of combination or to promote joint schemes, similar schemes between a number of companies or between local authorities and companies are denied, and even the supply from a single generating station of two or more districts scheduled under separate provisional orders but operated by a single company cannot be carried out without special Parliamentary authority; all powers granted to companies, if we except power companies, being subservient to the right of purchase of company undertakings by the local authority for the district.

Although from time to time we have been assured that the position of our electric supply industry was in no way behind that of other parts of the world, I question very much whether we can make the same statement to-day, in view of the rapid progress which is taking place in other countries at the present time. For our part, and I speak in a general sense of the whole electrical supply industry of this country, the progress of the past 10 years is surely nothing to boast of, in view of what might under more favourable conditions have been achieved. If we assume that our electric supply industry commenced in 1890—although a few undertakings were started earlier than

this—at the end of the first 13 years the annual consumption had risen to 247 million units in round figures, while in the next 10 years (1903–13) this consumption amounted to 1,318 million units, or an increase of 433 per cent. If the pioneering work of the first-named period is considered, few, I think, and least of all in this district, will be prepared to agree that the increase within the last 10 years represents the rate of progress which we ought to expect. The reason for this is clearly that the great majority of our undertakings by their operations on the restricted scale created by their condition of municipal isolation are not in a position to supply the larger users such as railways and industrial power consumers of all kinds. Nor is it possible that we shall ever be in such a position, so long as for sentimental or other reasons it is considered essential to retain a power station for each town or district, irrespective of its size or facilities for economical production. It is not surprising that under these circumstances an examination of the tables published by the *Electrical Times* shows that out of 287 undertakings whose generating costs are analysed (July, 1913) only five, or less than 2 per cent, have a works cost of 0.5d. per unit or under. Therefore, although it may sound like reiteration, we must first divest ourselves of this “one town one or more power stations” idea before we can hope to make any rapid progress.

That many of our undertakings are experiencing the pressing necessity for larger outputs and higher load and diversity factors is evidenced by the special efforts which are being made to develop electric cooking. To those of our undertakings especially whose operations are circumscribed by limitations of the area of supply, this development must be of a particular importance, and it is so far fortunate that their inability or unwillingness to improve their position by other possible means has compelled them to break new ground and direct their attention to the energetic development of this business. Meanwhile, unlike the small power business, which in many places has reached no unsatisfactory proportions, the development of the heavy industrial power supply over a large part of the country appears to be languishing, and yet how much remains to be done may be seen from the last Census of Production, which gives the total horse-power of engines in use at that date (1907) in the factories and mines of this country as 10½ million, of which 1½ million horse-power, or only some 14.3 per cent, represented the total plant capacity of public electric supply undertakings. More recent complete figures are not available, but some measure of the increase of horse-power available in our generating stations can be obtained from Garcke's “Manual of Electrical Undertakings,” which shows an increase of plant capacity between 1907 and 1913 of just over one-half million horse-power for those public supply undertakings which furnished returns, or rather less than the average rate of increase since 1890. I have been unable to obtain any figures bearing upon the total horse-power of engines in use in the country at the present time, but assuming for the purpose of comparison that no alteration in the figures has taken place elsewhere than in our public electric supply stations, our progress would be represented by an increase during the past five years of 4 per cent of the total. A further surprising fact shown by the last Census of Production is that there was approximately 1,000,000 h.p.

in private hands utilized for generating electrical energy, which produced an output equal to fully 62 per cent of the entire output of our public electric supply undertakings. Comment would be superfluous.

The most important development of the not very distant future will undoubtedly be the electrification of our railways. This branch of work, if we except the London tube railways, has not progressed as rapidly as we should wish, and many reasons have been advanced in explanation of this, of which perhaps the most important is the heavy capital cost of carrying out the conversion. This will, however, become of less importance as traffic further increases and as the alternative of carrying out heavy construction works becomes more and more pressing in the future. Steam locomotives have about reached the maximum dimensions allowed by the present load gauge, and the demand is still for heavier loads and more frequent traffic—two problems which electric traction is eminently fitted to solve.

Now as to the supply of electrical energy to work our railways. Are we going to repeat the mistakes of the past, and add to our already too numerous generating stations by compelling our railway companies to put down their own generating stations, as several have done already? This load, at any rate, is not one which for various reasons our municipalities can ever hope to touch, and there is, I think, no better illustration of the shortcomings of the present state of our electric supply industry having regard to its ability to meet all demands. It is certain that the ability to supply a likely demand will largely create such a demand, and if we wish to see a more rapid development of the electrification of our railways, the electric supply industry must place itself in a position to supply all the requirements of our railway companies at a rate which will induce these companies to undertake electrical working. It is not to be supposed that our railway companies would expend the necessary capital for putting down generating stations of their own if a sufficient, cheap, and, above all, a reliable supply were to be obtained from public supply sources, a fact which is already well recognized both in America and on the Continent, not to mention Tyneside.

It appears to me that here lies the key to the future position of our electric supply industry. There would seem to be but two alternatives once the electrification of our railways begins in earnest; either, as I have said, our public supply undertakings must then be in a position to undertake the supply of all the requirements of our railway companies, or our railway companies will themselves put down large generating stations, and, as a certain stage of their electrification developments, will inevitably seek to supply other undertakings in bulk. In either case the compelling agency will be that of larger outputs and the better load and diversity factors to be obtained by co-operation. The balance of advantage should obviously lie with us, who are first in the field, and who ought, but for the reasons which I have endeavoured to set out, to be in a position to supply a railway company's demand better and more cheaply than it could supply itself, having regard to all the economies rendered possible by a joint load. There is, further, a vast and practically virgin field in the supply of electrical energy for electrochemical and electrothermal processes, which, however, will only be secured

at rates which are but a small fraction of the present works costs of the large majority of our undertakings. In this field, so far, a few of the power companies stand practically alone, and chiefly those operating in this district, where, as a result of the electrical facilities offered, a number of important new industries have erected works adjacent to the power stations of these companies.

If our position is now relatively unsatisfactory when compared not only with other leading countries, but especially, and I think this is the more correct view to take, with what it should be considering our industrial supremacy and the density of our population,* it is surely a matter of the first importance that the causes which at present hamper the progress of the industry should be inquired into, and that the best means to remove these disabilities should be once more discussed and formulated in the light of present-day experience. This is a question, it seems to me, which the Institution cannot afford to ignore.

It will be of interest to observe that public electricity supply in Germany has developed on very similar lines to that of this country, in so far as many of the local authorities established their own works. Perhaps in one respect their condition was even worse than ours, for in 1909 it was estimated that 80 per cent of these municipal works were of a capacity under 500 kw. Germany is at present wrestling with this problem of the centralization of power generation, which we ourselves must eventually face, and is putting down large stations for a supply in bulk, many of them in connection with iron and coal companies, utilizing waste heat from coke ovens and unsaleable qualities of fuel. The co-operation of municipal authorities is being secured in some cases by buying out municipal undertakings upon terms advantageous to both sides, but more usually by giving these municipalities a financial interest in the power company. As an instance, the municipality of Strasburg takes the whole of its supply from a power company, in which it owns a large number of shares. This company supplies also some 70 communes in Alsace-Lorraine. As the result of the operations in 1909, the municipality received dividends and a share in the profits amounting approximately to £38,000, which, after deducting 4 per cent interest on its invested capital, left a balance of over £21,000 for the relief of local taxation. In other instances, groups of urban and rural authorities co-operating with a power company have the option of subscribing for ordinary shares in the promoting company, usually up to 40 or 50 per cent of the total capital, or in some cases, when wishing to avoid risk, to preferential shares with a fixed dividend and a further share in the profits. In each case the municipalities are directly represented on the board. The mutual advantages are obvious, in that the companies enjoy the benefit of the greater facilities afforded for raising capital, while the community through its directors maintains a live interest and a share in the control of the undertaking. Such schemes of harmonious co-operation it must be admitted cannot fail to hasten the solution of this problem.

* The density of our population in England is twice that of Germany, $3\frac{1}{2}$ times that of France, and $21\frac{1}{2}$ times that of the United States. This has an important bearing on the cost of transmission and distributing electrical energy, and is all in favour of the centralization of supply in the more densely populated countries, yet the more sparsely populated country is that one which has so far gone furthest in this direction, and vice versa.

It is perhaps in the United States of America, however, that the centralization of electric power production and distribution is making the greatest progress, and it is also remarkable that in that country the supply of electrical energy is chiefly in the hands of private enterprise. We have nothing to compare with the electric service in Chicago, with its maximum load of 230,000 kw. (compared with 20,000 kw. 10 years ago), or with more urban supplies such as the Public Service Corporation of Northern Illinois, which supplies 46,000 consumers in 150 communities, whose combined population is only one-half million, distributed over a tract 150 miles long, and has a load factor approaching 70 per cent. This load factor in itself is a striking example of what can be achieved by supplying various demands over very large areas. Another example, out of many which may be quoted, is the Central Illinois Public Service Company in the same State, which is gathering into one management and system the electrical requirements of a rural district of 350 miles radius (larger than the United Kingdom) with a population of only a quarter of a million, whose present 90 local generating stations will shortly be replaced by a small group of modern central stations.

The principle of State regulation of public utility services, which not only include electricity supply, but also gas, water, telephones, telegraphs, tramways, light railways, and railway services, is that which finds its adoption in the United States under the description of Public Utility Commissions. These Commissions, which are of recent origin and adoptive for each State, are appointed to deal with all questions relating to public services, such as the ratification of franchises, the settlement of disputes between undertakers, the revision of rates, amalgamations into joint schemes, the approval of new issues of share capital, technical regulation, and inspection, and not only to regulate but to press forward the development of such services. What the effect of these Commissions may be upon the ultimate development of the electric supply industry in the States cannot yet be judged, but I have looked in vain for any serious criticism by those most nearly concerned of the principle there adopted, while the remarkable strides which are taking place in the consolidation of central-station interests at the present time tend to show that their effect is on the whole beneficial.* It would seem, however, as if the municipal question obtrudes itself even here, as a few of the acts specially exclude municipally owned public utilities from the regulation of these Commissions, while there is further a "Home Rule" question; large cities, for instance, Chicago, seeking, so far without success, to establish their own Commissions in place of being merged in the more usual State Commissions.

The use of overhead wires in this country has always proved a matter of some difficulty, and some of the complaints which have been made from time to time have been as follows: The objection of the Board of Trade to the use of overhead wires; the difficulty of obtaining wayleaves across country, and the absence of legislative assistance in this matter; and the arbitrary powers granted to local authorities. With reference to the first of these

complaints, whatever may have been its attitude at one time, there is no doubt that for a number of years the Board of Trade, thanks largely to their electrical adviser, has facilitated the use of overhead wires in every possible way, with due regard to public safety. This must ever be our first consideration, and I do not think there are many of us who would wish to see erected in this country examples of overhead work, for instance, of the type common in large towns in America. But without going to such extremes in cheapness of overhead construction as is frequently met with there, there is yet a substantial saving in first cost, even with the very best construction, by the use of overhead wires in place of underground cables. The higher the voltage the greater the possible saving becomes; while at pressures exceeding 30,000 to 40,000 volts three-core cables for three-phase transmission can no longer be used, except perhaps in short lengths. It is only necessary to add that the power companies in this district have already 170 miles of overhead transmission lines, mainly operated at 20,000 volts, as evidence of the facilities which have been enjoyed for a number of years.

The difficulty and delays in obtaining wayleaves is a serious obstacle in the development of overhead construction, and our position in this respect compares very unfavourably with that of other countries, notably Italy and Switzerland, which have adopted legislation compelling the grant of wayleaves for overhead lines across private lands. Such works are there viewed as of public utility, and private interests are not allowed, subject to compensation, to take precedence of the general interests of the community. However much we may feel that similar legislation would benefit the electric supply industry, we have but to examine the privileges conferred by Parliament upon our Post Office—a State department with unusually wide powers. These are contained in Section 2 of the Telegraph Act, 1892, and Section 4 of the Telegraph Act, 1908.

While some attempt has been made to recognize the principles of public utility to which I have referred, the powers granted are in such a form as to render them of little or no practical service; in fact I am not aware that they have ever been exercised. We unfortunately cannot hope to obtain greater powers than the Post Office, which has a Cabinet Minister to look after its interests, and, further, such a different view is here taken of the rights appropriate to the ownership of land than is common in more democratic countries, that I am not at all sanguine of our being able to secure greater facilities from Parliament possibly within our generation.

It follows that the use of overhead wires for transmission purposes is at present to a large extent at the mercy of our landowners, but we in the north are fortunate in the fact that the land is largely in the hands of large owners, whose interests are so intimately bound up with the industries whose needs we seek to supply, or, if not, who are already so well accustomed to wayleave matters in connection with the mining industry, that, apart from delays, we do not experience the same difficulties as are perhaps strongly felt in some other parts of the country. The slow progress of negotiations is, however, a serious, but in the circumstances an inevitable, objection, which we must at present accept with the best grace possible.

The Electric Lighting Acts have probably done more to discourage overhead wires than all the rest put together by

* A leading New York banker has recently stated in an address that the electrical industry in the States can profitably employ a capital of £80,000,000 per annum for the next five years.

stipulating that before any overhead wires are erected the consent of the local authority must be obtained. It will probably come as a surprise to some present this evening to learn that this stipulation not only applies to the erection of overhead wires in public streets, but to all overhead wires, even if erected entirely on private land. It is difficult to understand what could have been in the minds of the framers of these measures, when we contrast the position of non-statutory undertakers with statutory companies. The former, of course, are not at all bound by the Electric Lighting Acts, with the exception of one single clause, to which I shall refer shortly. Thus an individual or company which does not work under an Act or Provisional Order can erect overhead wires on private land without the consent of the local authority. Further, such an individual or company, in the absence of special local by-laws, of which very few are in existence, can erect overhead wires across public roads without seeking any consent from the local authority, provided the consent of the owners of the soil on each side of the road is obtained, and also that the wires are erected at such a height above the roadway that no obstruction is caused. Lastly, non-statutory undertakers are not compelled to erect their works in the first instance in compliance with any regulations of the Board of Trade, except that under Section 4 of the Electric Lighting Act, 1888, it is provided that the Board of Trade may, if it thinks fit, serve a notice upon the owners of such overhead lines requiring that they continue to be used only in accordance with such regulations as the Board may prescribe. As the Section of the Act referred to was obviously intended to bring under the control of the Board of Trade all overhead lines erected by non-statutory owners previous to the passing of this Act, it is somewhat extraordinary that the serving of a notice upon the Board of Trade before the erection of further lines was not made compulsory under the Acts. Non-statutory owners, such as iron and steel manufacturers, collieries, and others, have therefore a roving commission to erect overhead wires on private land and, with few exceptions, across public roads without seeking the consent of either the local authority or the Board of Trade. In my opinion it is essential that an early opportunity should be taken to amend the Electric Lighting Acts in this respect, for if, as all agree, regulations are essential in the case of statutory undertakers, how much more are they necessary in the case of non-statutory bodies, who are usually the least qualified by reason of their not being primarily engaged in electrical work, and whose interest in the matter is frequently limited to considerations of the lowest tender.

Efforts should also be made to secure a curtailment of the absolute veto of the local authorities in regard to overhead wires, particularly if it be not proposed to erect these wires along public thoroughfares, and the local authorities' consent should in all cases be made subject to an appeal to the Board of Trade. At present such an appeal is only allowed in the single case of power companies' wires in rural districts, but in the case of all other companies' overhead wires, or with power companies in the case of overhead wires in urban districts and boroughs, there is no appeal whatever from the decision of the local authority, which is thus entitled to refuse its consent, or to attach unreasonable conditions thereto, without any further means of redress being available to these companies.

I would not have it thought that I am in any sense advocating a general use of overhead wires in place of underground cables. Both have their uses, and I think the more legitimate use of overhead wires in this country in the future will be for transmission lines across private land and at very much higher pressures than are used at present. A further consideration in the use of higher transmission pressures in this country is the practical impossibility, for many and various reasons, of erecting an entirely continuous overhead system, and most of our overhead lines must of necessity include a fair percentage of underground cables over sections of the route; therefore, whatever pressure may be adopted for the overhead system must also be suitable for use with underground cables. This leads to an examination of the high-voltage cable position. No very notable advance can be recorded since the laying of the extensive 20,000-volt three-phase cable system in this district some seven years ago, if we except a large system of 30,000-volt three-phase cables laid in Berlin about two years ago, following upon the experience obtained here. There are, I understand, some short lengths of 45,000-volt three-core three-phase cables in use in France, but, as far as I know, this is the highest pressure hitherto applied to three-core cables in commercial service, and it is difficult to foresee any possibility of exceeding this or even much lower pressures on a large scale on account of the heavy capacity currents and increased dielectric losses (which, it must not be overlooked, are continuous losses and independent of the load) which would be experienced at our usual frequencies. While with cables these losses increase in proportion to the square of the voltage, they are practically non-existent on overhead lines up to the limit of pressure at which corona effects take place. Another factor which largely determines the highest pressure that can economically be dealt with by an underground three-core cable is the maximum diameter and weight of cable which can be handled. Beyond this, it is necessary to resort to the use of three single-core cables at a greatly increased cost. At present I would set down the superior practical limit of pressure for three-core cables at not more than 40,000 volts, while there is no very obvious difficulty in constructing single-core lead-sheathed cables for three-phase work up to a working pressure of 50,000 volts per cable—that is, over 80,000 volts between phases with the neutral point earthed. Capacity currents and the copper and dielectric losses to which they give rise, and also sheath losses arising from the use of single-core cables, would not prove of such serious importance if these cables were used as an adjunct to our overhead lines in moderate lengths, distributed as usual at points along the route. I therefore apprehend no serious difficulty in increasing our overhead line pressures to anything between 60,000 and 80,000 volts if required.

Considering the importance of the subject, our knowledge of the science of cable design is still very incomplete, and although the general principles are fairly well established there is a remarkable dearth of technical data upon the properties of extra-high-tension cables. It is evident, for instance, that our thicknesses of insulation for extra-high-tension cables are in many cases unduly liberal and purely arbitrary. From what we know of potential gradients it is clear that a thickness of insulation

which will be correct for a large size of core, as, for instance, 0.25 sq. in., will not necessarily be correct for a smaller core, or for a round core against a clover-leaf core. The potential stresses will be relatively much greater in each of the last-mentioned cases, and yet we find that our engineering standards do not discriminate between such cases, but even allow thicker insulation on the larger sizes of cables compared with the smaller. It is no wonder that many of our paper cables frequently show factors of safety of 10, or even more, under test, and we might well refer to such as factors of ignorance. One cannot commend our lack of enterprise in research. While our cables undoubtedly rank as the best in the world, this position has been arrived at more as a result of careful attention to details of manufacture than by the application of scientific principles to design. Although there are happily signs of an awakened interest in this matter, still there appears hitherto to have been no co-ordinated efforts to place it upon a sure foundation, and yet I feel confident that a full investigation should enable a reduction to be made in our thicknesses of insulation, with a consequent saving of possibly anything from 10 to 25 per cent in the cost of extra-high-tension cables (6,000-volt and upwards) as the result of smaller overall diameters and the consequent cheapening of lead sheaths and armouring. This question is one for further investigation, but in the meantime we may take some comfort from the prospect that many of our existing cable systems are capable of being worked satisfactorily at much higher pressures than those for which they were originally laid down.

We may look to see some interesting developments in the utilization of waste gases within the next few years, both for the production of electricity and for town gas lighting. Use is already being made of coke-oven gas for town lighting in Germany and America, and, to come nearer home, the town of Middlesbrough has just entered into a contract with a firm of ironmasters to take the whole of their town gas supply from coke ovens; while another interesting experiment is that of the Birmingham Corporation, who have installed some coke ovens primarily to produce town gas and to dispose of the furnace coke produced as a by-product. Seeing that coke-oven gas should be obtainable at some figure below 6d. per 1,000 cubic feet, keen competition may be anticipated in those districts where such gas is available. The utilization of waste heat to its fullest extent for electrical purposes is only possible to those power companies with widely ramified networks, as much of it is only available at a distance from the large centres of population and chief points of power utilization; but by feeding into the main network at so many points remotely situated from the chief power stations considerable economies in the transmission system and its losses may be

attained. Of course there are objections in the way of its rapid adoption, such as the limited quantities of waste heat usually available at any one plant, which would result in heavy capital cost for small stations; but when the use of by-product recovery ovens becomes more general it will doubtless in some cases be possible to concentrate the generating plant, the gas being piped from a number of near by-coking plants to a power station placed at some point favourably situated with respect to these sources of production. Another, and perhaps at first sight more serious, objection is the liability to interruptions from labour troubles and industrial depression, resulting in the shutting down of the producing plants. Some alternative method of keeping the station plants in operation, such as coal or oil firing, or producer or oil gas if gas engines are used, would be desirable at some of these stations, but not necessarily at all. This might in these cases be necessary to maintain the general scheme of distribution in the transmission system, although loads would obviously be very much diminished in such circumstances.

I do not think I need pursue these and other technical aspects of the problem of the centralization of power supply any further. The hindrances to our progress are by no means technical in character, and it is true that the world's achievements in electrical and mechanical engineering are far in advance of any of the possible requirements of this country for many years to come. When we learn, as from the States, of 30,000-kw. turbo-generators, of which seven are already under construction, the daily operation of high-voltage overhead transmission up to 140,000 volts and covering distances up to 240 miles, of 300,000-h.p. central-station developments and the electrification of some hundreds of miles of main-line railway, we need have no fear as to the ability of engineers to keep pace with the world's industrial demands. But for ourselves can we ever hope to maintain our position in the electrical engineering world if we are content to allow our electric supply industry to develop along its narrow way; indeed, have we not already lost too much ground? What training ground shall we offer the rising generation of British electrical engineers if we wish to take our part in the electrical development of our Empire overseas, and how shall our electrical manufacturers assume their proper place in the markets of the world when handicapped at home by a restricted market, which might easily be increased to many times its present proportions? Truly this question is more far-reaching than may appear at first sight. It is not my intention to discuss here the seemingly delicate question of how one may best reconcile the different and admittedly powerful interests which at present operate to the disadvantage of our industry, and I shall esteem my task well done if I but succeed in turning your thoughts in this direction.