140.

Register

20 AUG 1924

Myriad Services.

Phenomenal improvements in electric lamps, following the researches of Edison, Swan, Coolidge, Langmuir, and many others, established illumination by means of electricity in an unassailable position from which it had ousted all its rivals. It was almost exclusively in the field of electric lighting that the young industry of electric generation, in its growing years, found commercial support and encouragement. Its extension on a vast scale to wider and more varied uses was a comparatively recent development. The experience of very recent years had shown that there was practically no sphere of human activity where electricity might not be advantageously used—scarcely any important material service which it could not effectively render, whether in the supply of motive power to operate moving mechanism of all kinds, great and small; whether it be for industrial, rural, or domestic purposes, including, as a major service, land transportation of passengers and merchandise; in the supply of heat for warming, for welding, for smelting, for refrigerating, or for cooling; in chemical and metallurgical processes; in the diagnosis and therapeutic treatment of disease; and in wireless inter-communication. Those numerous and diverse applications of electricity had already reached proportions far beyond the expectations of the most sanguine thinkers of 20 years ago. The "saturation point," or limit of electrical application, however, was yet far off, and had not been even remotely approached in any single country. Therefore it was plain that a vast preparation must be made for the future.

Astonishing Figures.

Three years ago the world had reached astonishing figures of electrical consumption. The world's estimated total rating of actually installed generating plant exceeded 46 million kilowatts, or over 60 million horsepower; the world's total consumption of electrical energy had reached, roundly, 100 thousand million "units" per annum. Of this total, Australia was responsible for only 600 million units, or less than 1 per cent. of the world's total. The deductions from these statistics were even more striking. The consumption per capita per annum was shown to vary widely in different countries. Switzerland headed the list with a consumption of over 700 units per head per annum; Canada closely follows with 612; and then they had in succession, Norway 493, United States 472, Sweden 364, United Kingdom and Ireland 139, while the consumption over the whole of Australia averaged, in 1920, only 110 units per head per annum. Switzerland, with a population less than that of the Australian eastern coastal fringe, consumed five times as much electrical energy. In spite, however, of the high figures of total consumption, it also appeared from those records that in no country did the number of dwellers in electrically lighted abodes reach 40 per cent. of the whole population. So far back as 1920, which in electrical matters was already remote, no less than four of the countries dealt with, had a consumption exceeding 400 units per capita per annum. There was no reason that could be suggested why the Australian people should not rapidly reach such a consumption and pass far beyond it, especiayy as, in Australia, a very high percentage of the total population was congregated in a few large cities.

It appeared to the lecturer in the not distant future the consumption would probably be reached in the capital cities and industrialised areas would be roundly 1,000 units per head of the population per annum. In that estimate he had taken no account of the great users of electrical energy which were coming into the field such as the various forms of electro-chemical industries. Neither had he made any special reference to the use of electricity as farm power, alhtough it required no great imagination to visualize the possibility of the application of electric energy to almost every form of agricultural procedure; and such developed uses might readily, in course of time, lead to a rural consumption, at least as intense, when measured at per head of population, as that envisaged for the dwellers in the larger communities.

Future Power Wants.

He asked them to follow him and see where those consideration led them. If they assumed the population of Australia at roundly six millions, and, further, that the great majority existed within the sphere of influence of an electric system, it would be seen that the visible prospective consumption of electrical energy, by the present population of the Commonwealth, amounted to close upon 6,000 million "units" per annum. If they further assumed that consumption represented the use of the maximum load during as much as 12 hours in each day (a very conservative assumption), the "maximum demand" upon the whole of the electric supply systems of Australia would then have reached over one and one-quarter million kilowatts, and generating plant of that available capacity would have had to be provided.

"Taking, as a special example, the State of Victoria, whose population is so disposed that almost the whole of it lies within the economic range of centralized electric suppy," said Sir John, "then the total installation which would be required in order to meet a consumption of the order speculated upon, would amount to a capacity of 370,000 kilowatts, or, roundly, half a million horsepower. This figure is more than three times the total capacity of all generating plants at present available or under construction in that State. Here, then is a development problem of first-class magnitude in both its engineering and financial aspects."

The conclusion was obvious that the immediate attention of scientists, engineers, and statesmen was required to the problem of satisfying the demand for electric services which was confronting Australia; that they must evolve far-reaching plans for meeting the situation; and that they would have to take exhaustive stock of their various resources for power production, and estimate their respective extent and capacity.

Sources of Power.

The immediate effect of progressive achievements in the transmission of electrical energy over long distances, the lecturer resumed, had been to increase, almost beyond estimation, the available sources of energy. Apart from the water power thereby made available, the chemical energy of untold stores of fuels of such low grade and poor calorific value as to prohibit their economic transportation could be locally converted into electrical energy for transmission to the distant place of use. Those poor grade fuels—of which the lignites and brown coals were typical—exist in far vaster quantities than black coal; but those great resources had scarcely yet been touched.

The two great sources from which the world's requirements of electrical energy could be drawn were water and fuel of all grades. Many people thought water power was much the cheaper. That was misleading. Water power was not necessarily, or even generally, cheaper than heat power. Neither could the whole available water power resources of the world provide even fractionally for the ultimate needs of mankind. Australia had to look principally to its fuel resources to meet the all-important demand for energy which were developing.

Fuel Resources.

Dealing with fuel resources, Sir John said that in actual production of fuel in the form of coal, lignite, and fuel-oil, there had been no material increase throughout the world in recent years. Since the war the world's annual production of fuel of all classes had ranged about 1,200 million tons per annum. Australia's contribution to the total was 13 million tons, or 1 per cent. It was interesting to note that the fuel produced in Germany comprised black coal and lignites in almost equal proportions, although the output of lignite in that country is rapidly overhauling and outdistancing that of black coal. That growing ascendancy of brown over black coal was due not to any deficiency of supplies of the latter, but because the methods of production and utilization of the brown coal—though of relatively poor grade—enabled it successfully to compete commercially with black coal.

It was not improbable that the proportion of the world's population which was employed in mining for fuel had reached a maximum, and that therefore, the peak of production of fuel energy, in the "raw" form of coal and oil, had been reached. The only hope of meeting their increasing future needs was by seeking and practising methods of far greater economy than were in use at present. Those economies lay in two entirely distinct directions, firstly in lowering the cost of production of fuel by an ever-increasing substitution of mechanical processes for physical labour in the winning of the fuel, and secondly, in a progressive increase in fuel economy by improvements in furnace, boiler and turbine efficiency; or the possible discovery of means for converting the chemical energy of fuel direct into electric energy. In those directions lay a fascinating field of research for the physicist, the chemist, and the engineer. A forecast of the future requirements of energy in Australia might be conveniently based upon the actual experience of the United States. In that country, the production of black coal per capita per annum was in 1860 one-half of one ton. It rose comparatively slowly in succeeding decades, until in 1890, it had reached 2½ tons per capital per annum. This is a little more than the production of Australia at the present day. By 1900 it had risen, in the United States, to 3½ tons, in 1910 to 5¼ tons, and in 1920 to 6½ tons of black coal per capita per annum. If they looked forward to the time when the population of Australia would have reached 50,000,000, and if they assumed that by that time their continent would have reached a demand per capita no greater than that of the United States today, then they must predict that their population would then require the production of energy, amounting to the equivalent of 300 million tons of black coal per annum. That problem was happily, already receiving more than casual attention, and it was upon the labours of the scientist, more than upon any other agency, that they had to depend for meeting the imperative requirements of their future state

The Present Position.

"We can now take stock of the position which has been reached in the actual practice of power development," Sir John resumed. "The two major problems are firstly, the economic production or generation of electric energy, and secondly its economic transmission to the places of its use. An examination of the present state of knowledge and practice in these fields shows that the former has reached a stage of very considerable complexity, with, nevertheless, a low standard of overall absolute efficiency, but that the art of transmission is relatively simple, and has attained a high efficiency." Wind actuated machinery and the utilization of the potential energy of tidal [illegible] so costly that they could be dismissed from their calculations at the present, insofar as their application to general commerce was concerned. For practical purposes they were to-day concerned in the matter of water power, only with the use of the flow of streams and rivers by taking advantage of the natural descent of their water from the higher to the lower levels. American investigations had led the way in the matter of turbine efficiency and in 1923 that efficiency had reached to 90 per cent., and the capacity of hydraulic units was increasing from year to year. Although such high "efficiency" had already been accomplished, there was hope that further research and experiment would lead to still higher efficiencies and still greater economies in converting the potential energy of falling water into motive power.

Heat power was applicable to electricity generation in many forms. All those methods had been in use in some form or other for upwards of 25 years, but the majority of them, principally in relatively small private industrial installations. Among them all, steam, produced by the combustion of high and low grade coals, had survived as the most adaptable to the demands of electric generation on the grand scale. Sir John then reviewed the evolution of steam in relation to power. He continued that by successive steps they had reached the highly developed compound condensing steam turbine, as the prime mover of the same revolving shaft upon which is mounted the electric dynamo or alternator; so that they had in a single unit of mechanism, the turbo-alternator or turbo-generator. The evolution of that apparatus had occupied nearly the past 20 years, and there was yet no indication of any radical innovation in steam prime movers which was likely soon to displace the turbine principle.

The application of the turbine principle to steam had been the most potent of all the factors which had rendered possible the creation of the great heat power systems which were now in process of development throughout the world. Nothing remotely approaching the possibilities definitely in view could have been accomplished if they had had to rely upon the reciprocating steam engine in general use 15 years ago. Year by year, the size of single generating units had progressively increased, and to-day gigantic individual machines, of remarkable reliability, capable of an output of 80,000 horse power were being installed in some of the super-power stations of Europe and America. The fact that the installation and operation of those high-capacity machines would simplify the problems of the operating engineer, responsible for the supply of energy to the congested industrial and city areas of the world, needed no emphasis. Associated with those developments had been also the introduction of even higher speeds of revolution of those turbo-generators. During the days of the war, speeds reaching 1,500 revolutions per minute had been achieved, and during post-war days the bewildering rate has been actually doubled. Turbo-generators of capacities up to 20,000 horse power were already installed and in operation having a rate of 3.000 revolutions per minute, or 50 complete revolutions in each second of time. Those recently put into operation at Newport, in Victoria, were examples. The intricacies of the lubrication and temperature regulation, incidental thereto, which had been successfully solved, he left to the imagination

At the present time they had reached the stage when a turbo-generator, operating under full load conditions, at a rate of 3,000 revolutions per minute, could be so completely controlled that, in the event of the load being suddenly reduced by half, or even, as the consequence of some general breakdown of the system, entirely "switched off," the rate of revolution would not vary by more than 3 per cent.; while during normal operation a variation of less than one-half per cent. was attainable. The introduction of that governing device had led to a greater reliability and to a greater simplification of operation of turbine plant than any other improvement that could be cited.

Fuel Economy.

The development of the steam turbine had naturally called for corresponding improvements in steam-raising plant, not merely as regards capacity, but also as to greater fuel economy and greater flexibility in order to meet the widely varying demands of the plant for steam, from hour to hour. That had led to the almost universal adoption in all modern large heat-power stations of the water tube boiler, the chief merit of which, as compared with the older "shell" type, was the saving of space, and the ability to meet very rapid demands for steam. Concurrently, there had been a gradual increase in the steam pressures generally employed, which had risen from 200 lb. per square inch—recently considered a maximum—to 260 lb. per square inch as the standard practice of to-day. That was proving only a temporary halting place, for already some power house boiler plants had been installed with steam pressures ranging between 300 and 500 lb. per square inch, while a new power house at Chicago was being actually projected to operate at a steam pressure of 1,200 lb. per square inch. It remained, however, to be seen whether the increase in efficiency attainable by the use of those super-high pressures, when offset against the greatly increased capital cost and difficulties of construction and operating maintenance under such extreme pressures, would justify their more extended adoption. As a result of the investigations a given quantity of fuel can to-day be made to yield more than three times the quantity of electric energy that was possible 25 years ago. That the maximum of "efficiency" in generation of energy had been reached could not for a moment be entertained. But it was not easy to forecast the line of further development. An interesting investigation was being pursued in the "Benson" boiler, which aimed at pressures reaching the point at which the latent heat of steam became zero, and there seemed some justification for the expectation of radical improvements flowing therefrom. Then there was the first commercial installation of a plant at Hartford, Connecticut, U.S.A., which proposed to use the vapour of mercury, instead of the vapour of water, the results of which were being eagerly awaited by power engineers the world over. The mercury was vaporized by coal or oil, and was first used to drive a turbine direct, then to raise steam in an ordinary water boiler, which steam was used to drive another turbine. After thus performing two functions, the mercury vapour was condensed back into its ordinary form, to be used over and over again, ad infinitum.

Intermittently, for many years, experimenters had attempted to develop the gas or internal combustion turbine, but, so far, no commercial success had been reached. On the other hand, internal combustion oil engines had made a distinct advance during the last 10 years for use in power stations of smaller size. The possibility of a development of that type for heat engine in superpower houses could not be rejected.

Pulverized Coal.

Before leaving the subject of heat energy, Sir John made mention of recent developments in pre-treatment of the fuel itself. The pulverization of coal, and its introduction in a pulverized form into the furnace by means of a jet of air, had received a considerable impetus during the last six or seven years. By such means it had been found possible to produce economic results with fuels which had often previously to be discarded. Even in locations where high-grade fuel was obtainable, there were some notable instances of power stations employing pulverized fuel, with commercial advantage, in spite of the high cost of its preparation. The resulting advantages of flexibility in operation and closeness of air regulation had led to particularly high efficiencies.

The net result of researches and experiments now in progress in many countries might well be to cut in half the quantity of fuel consumed per unity of electrical energy generated. Signs were not wanting that the production of fuel, in the most usual form of coal, by underground mining, being an extremely distasteful form of labour, would in future be tolerated only with limitations ever more closely drawn. Its increasing cost was a symptom of that, and that was a consideration which was exercising a potent influence in directing the energies of many investigators. In order to indicate that the labours of electrical engineers had not been resultless in the direction of fuel economy the lecturer quoted from the report of the electricity commissioners of the United Kingdom, issued last May, which showed that, as compared with the preceding year (1922), the total annual output of electric energy in the United Kingdom disclosed an increase of 17½ per cent. over the immediately preceding year; but that the corresponding increase in the annual consumtion of fuel for that purpose had been only 3 per cent. The average consumption in coal-fired stations had been 3.11 lb. of coal per kilowatt-hour in 1922, but only 2.78 of coal per kilowatt-hour in 1923, or a saving of 10.6 per cent. within a period of 12 months.

Generation and Transmission.

Referring to the developments in the design of the generator end of the combined turbo-generator unit. Sir John said the modern generator was nothing more than a high development of the epoch-making discovery made nearly a hundred years ago by Michael Faraday, who might be truly honoured as the father of the science of electro-magnetism. It sufficed to say that it was in that apparatus that the kinetic energy of the steam turbine, actuated by the heat energy of the steam, was converted into electric energy, capable of instantaneous transmission for hundreds of miles. It could not be said that there had been any very revolutionary principles in the design of "generators" as practised for the last 10 or 15 years. Nevertheless, a great amount of effort had been applied to a closer investigation and understanding of the metallic and divers other materials employed in their construction, which had resulted in definite progress. There had been a general progress in the solving of the problems surrounding the dissipation of the heat losses which occurred in the machines during their operations. Sir John went on to refer to the manner in which knowledge and skill had been devoted to the solving of the many problems of transmission. He said that electrical energy, speaking broadly, was commercially usable only at comparatively low pressure ranging from 100 to 500 volts. Except in wireless transmission or in therapeutics, the industrial employment of very high voltages was rare. To achieve economy in the design and construction of transmission lines, it was essential that high and sometimes super-high pressures must be employed. The greater the distance and the greater the load, the higher was the pressure required. The use of a prssure of 220,000 volts, for the transmission of energy, was no longer experimental.