is concluded that separate mechanisms, responsible for (*a*) the removal of growth inhibitors, (*b*) elongation and (*c*) division, become adapted at different rates to the new medium.

Dr. G. H. Spray and Dr. R. M. Lodge described the effects of resorcinol and *m*-cresol, which cause a prolongation of the lag rather than a slowed rate of growth, or a diminution of the stationary population. Resorcinol is eventually completely inactivated by the bacteria, but *m*-cresol is not. Long, snake-like bacteria can be produced by *m*-cresol under certain conditions. Dr. D. S. Davies and Prof. C. N. Hinshelwood described the effects of sulphonamides, which both increase the lag and reduce the growth-rate, but do not inhibit growth completely even in high concentrations. On subculture in the presence of sulphonamides the organisms become immune to the drug. Thus immunity is at first partial, reversible and specific to the particular sulphonamide (sulphanilamide or sulphaguanidine) used. After thirty subcultures it becomes complete, irreversible and unspecific. The theory that this is due to the selection of resistant organisms is rejected, and it is assumed that the cells develop enzymes which produce a sulphonamide antagonist. The partial antagonism which develops earlier is probably due to other causes.

A full account of the meeting will appear in the *Transactions of the Faraday Society*.

J. H. Gaddum.

AREA HEATING

The publication of recent technical papers* on so-called district heating emphasizes a grave omission in the County of London Plan; indeed, the term is mentioned a few times, but there is no consideration of the very great contribution this development of applied science can make, on several grounds, to the social development of large population groups which have arisen in Great Britain, especially the conurbation of London. The subject is very briefly mentioned in the exhibition of planning now open at the Institution of Civil Engineers, held jointly by that body and the Institution of Municipal and County Engineers. Twice in the last twenty years St. Marylebone Borough Council, which generates its own power, discussed supplying the local housing estates with heat, but failed to grasp the opportunity of obtaining experience in this field.

There is a ray of hope, however; Coventry has just agreed to incorporate district heating in its reconstruction programme. The local authority still has to convince the Electricity Commissioners, and then bring a Bill before Parliament. Further, the Public Works Committee of Bristol has had submitted to it a plan to cover the central area of that city.

The major public difficulty is that the existence of district heating is not obvious. It is not like a railway, bridge, or power-transmission line, which anyone can observe or appreciate for use or value. District heating is not known in Great Britain, whereas it is a national policy in the U.S.S.R.; Russian schemes already dispose of more heat than is conveyed by all the town-gas in Britain. Hamburg has had it on an increasing scale for half a generation, and each of the latest German schemes is larger than the New York plant, which uses 775,000 tons of coal annually.

What, then, are the virtues of district heating? Practically all electric power in Great Britain is generated by high-pressure and high-temperature steam, dropping its entropy in turbo-generators. The maximum working efficiency of energy conversion from coal to electricity is not likely to exceed 30 per cent in the most modern, and consequently all new, power stations; it averages 20–25 per cent. The major loss is in the condensation of the steam at low-pressure, necessary for the operation of steam turbines; that is, the latent heat is wasted. In other words, every large power station is throwing away a million kilowatts continuously into the local river or its cooling towers.

The usage of electric energy is increasing at a rapid rate, and in many large places, which provide centres of gravity of electric loading, new power stations will be required. London after the War will, it is probable, require several new power stations or great extensions to cope with the increasing load. The more electric energy is used under the present system, the more coal energy is wasted. The natural and obvious proposal is to utilize this wastage of heat for domestic and process work in the neighbourhood of these power units.

Continental practice shows that a distribution of this waste heat is easily economical up to seven miles, and, in favourable circumstances, several times this. It is calculated that with reasonable capital expenditure, which can be amortized in between five and fifteen years, depending upon the particular circumstances, such heat can be sold at not more than 4*d*. per therm; this would make important contributions to coal conservation.

A more attractive scheme is to burn the coal in boiler stations, in which can be realized efficiencies of conversion up to 90 per cent, on the rim of large centres of population, transmit the steam through large pipes to turbo-generators located at the centre of gravity of the electric load, and dispose of the heat, which otherwise would be wasted, in the surrounding domestic and industrial areas. The wastage of heat in such pipe transmission is of the order of 1 per cent for seven miles, because of the very large diameter required; the pipe need not be lagged with heat-conserving material. In one step we save the expensive area required for a coal depot essential now to every power station, the consequent dirt which arises from coal and ash handling, and any more which is permitted by expensive smoke cleaning plant to escape through unsightly chimneys; we have saved not only the cost of expensive condensing plant, and cooling towers on non-river sites, but also, in the latter case, expensive ground and the enormous amount of condensation which is inevitable in their region during humid weather. The problem of noise arising from generators in a comparatively small building can easily be coped with by modern methods of noise control.

Having decided to dispose of hitherto wasted heat —and it may be remarked that it is not possible to extract much heat from existing power stations because the full benefits are not realizable without special designs of back-pressure turbines—the problem is to distribute such heat in the form of hot water or steam at high pressure to the situations where it can be utilized. Naturally, the regulation of demand, which would not be exactly in step with the electric power demand, causes some difficulty, but this can be overcome by having adjustable back-pressure on the turbines with suitable heat-reservoirs, these taking the form of lightly heat-insulated steel water-

* *Electrical Times*, Sept. 30 and Oct. 14, 1943; *Engineering*, Oct. 8, 1943; *Industrial Heating Engineer*, July–Oct. 1940.

towers; the pipe-lines would be tapped to convert the heat through thermostatically controlled calorifiers in consumers' premises. The County of London Plan, with its new roads, both radial and ring, offers not only suitable routes for the large piping which would be required for the main heat transmission routes, but also, since these routes go through areas which are intended for planning on the ten-story-block-of-flats principle, the latter could be designed immediately for district heating with a minimum of capital expenditure, thus saving valuable boiler accommodation and fuel storage.

With regard to competitive forms of heating, the Engineers' Study Group on Economics, collecting information from many organizations, had previously deduced that it is in the national interest to use gas rather than electric power for basic domestic heating, the point being that if large sections of the population could be persuaded to abstain from wastefully using soft coal in domestic hearths and to use coke or other low-temperature carbonized coals instead, it will be necessary, in order to provide such hard fuel at reasonable cost, economically to get rid of great quantities of the minimum gas which is necessarily involved in producing any specified quantity of hard fuel. Prof. C. L. Fortescue, in an informal discussion at the Institution of Electrical Engineers, also arrived at the desirability of increased domestic heating by gas from other arguments. Thus there is competition on technical, social, and economic grounds between district heating by waste-heat from power stations, and domestic heating by means of gas. Electric power is so precious and high-grade that it must be considered out of the question for basic domestic heating, except in special circumstances.

A further reason for the usage of gas for basic domestic heating is the technical one of regulation. It is well known that in suburban areas in which domestic gas-cooking is prevalent, the drop in pressure at the peak-loading, especially for Sunday dinners, is serious. It is therefore desirable to use electric power for cooking, because of its high regulation, which is also essential for lighting and normal power requirements. We are thus led to conclude that electric power should be reserved for those applications where good regulation is desirable, and gas should be used where, through automatic control, such as in gas central heaters, which have been hitherto little used in Great Britain, close regulation is not essential.

What case, therefore, can be made for district heating? It must be based on the fact that electric power is increasingly demanded, and therefore there is a waste of energy, as explained previously. It follows, therefore, that in the national interest district heating should be used where practicable and economic, the gaps being filled by gas. Electric power should be reserved for those applications where it is most effective, such as electric traction, electric lighting, and the manifold large and small power uses where its delicacy of control gives it an advantage over any other competing form of power.

On social grounds, district heating would, at one stroke, if carried out on a large scale in large centres of population, dispose of the necessity of the traditional domestic fire and the consequent wastage of heat into the open sky, the pollution of the atmosphere with unconsumed carbon, and the wide-scale deterioration of buildings because of the sulphur acids emitted into the atmosphere. The point here is that whereas in large power stations the exhaust gases can be cleaned efficiently, or so dispersed in countryside areas that their effect on man and Nature is substantially zero, there can be no such control over the tiny combustions which occur, to the number of millions, in domestic premises. The general adoption of central heating which has taken place in other countries may not be desirable in Great Britain; in fact, the ideal for our more moderate but erratic climate would be semi-central heating, topped up with a small amount of radiation, gas or electric. In this way the great value of our climate—its variability between extremes which are small in comparison with climates in other parts of the world—is conserved, both indoors and without.

L. E. C. Hughes.

OBITUARIES

Mr. A. C. Gardiner

Alan Gardiner died on August 29 at the age of forty-six. The news came as a great shock to his many friends, and hydrobiology suffered a severe loss. He was educated at Oundle and Gonville and Caius College, Cambridge, and inherited a love of science from his brilliant father, the late Dr. Walter Gardiner. As soon as he had graduated in 1920 he began the line of research which always continued to attract him: the problems of plankton ecology, sometimes freshwater, sometimes marine, and refinements in the methods of attack. This work, although broken by periods of illness, was always taken up again, and he was actively pursuing it at the time of his death.

His first investigations, in collaboration with the late Mr. Rowland Southern, were made over several years from a floating laboratory on the River Shannon where it flows into Loch Derg. The amount of data they amassed, biological, physical and chemical, was enormous; in studying the diurnal migration of the animals they at times kept up their sampling and recording at intervals through the day and night for a week or more on end. The working up of all this material took many years, and their splendid studies of lake and river plankton appeared at intervals from 1926, long after the field work was completed. Southern died in 1935, but Gardiner finished the great work in 1938.

Leaving Ireland, Gardiner was appointed in 1924 to the research staff of the Ministry of Agriculture and Fisheries and took up the problems of freshwater biology in relation to pollution at the ministry's laboratory at Alresford. Here came his first serious breakdown in health, and he was forced into exile to Switzerland. On his return he joined the marine Fisheries Laboratory at Lowestoft and devoted himself to such problems as the effects of patchiness in distribution upon the validity of plankton sampling, the quantitative efficiency of nets and the vertical distribution and migration of plankton animals. Ill-health forced him to resign and go back to Switzerland where, as he wrote in a letter, he was teaching "Chemistry, Mathematics, 'As you like It' and 'The Acts of the Apostles' in a school for backward boys".

Better once more, Gardiner was appointed in 1935 to the staff of the Metropolitan Water Board and threw himself enthusiastically into seeking solutions to the many problems of waterworks biology. He was particularly concerned with the factors under-