Water Pollution and Purification*

THE subject of water, its sources, properties, behaviour under various conditions, uses, etc., is of interest to everyone; and as the work of the Water Pollution Research Board touches on every aspect of these questions, the annual reports of this body are of prime importance.

Droughty weather during the past three years in Great Britain has brought the vital question of the conservation of good water to the fore, and the present report indicates that the Board is continuing its work of accumulating accurate information as to how this may best be done in co-operation with other bodies. Perhaps the most fruitful work of the Board results from its efforts not only to control and prevent the fouling of good water, but also to further the means of reclaiming water economically and expeditiously, which has been fouled by industrial or domestic use.

The report shows that work of this character goes on steadily, and ultimately must produce most far-reaching benefits to the community. For example, the ever-present difficulties and losses in industry due to the hardness of water are of universal concern; and for some years now, the Board has directed detailed researches into the question of water softening. More particularly this work has been directed to the investigation of the base-exchange or zeolite process of water-softening; and a most useful review of the work already accomplished together with further results is given. "The process utilises the property of base exchange possessed by certain hydrated alumino silicates." The properties of materials, whether of mineral or synthetic origin, are discussed; their limitations as softening agents, liability to disintegration, etc., are indicated; and it is very evident from the information given that considerable care is necessary in installing and manipulating such a plant.

A table is given showing the "Base-Exchange Value and Weights per Cubic Foot of Representative Commercial Materials" including mineral non-porous and porous (both dry) and also synthetic material (damp as delivered). "With equal weights as the basis the exchange value of the synthetic material was 2½ times that of the porous mineral, and five times that of the non-porous mineral." Much detailed information respecting the behaviour of the materials with different kinds of waters is contained in this part of the report, and a note of caution is sounded when it is stated that "Relative costs and other factors must also be taken into account". A point of interest is that the synthetic products are gels, and are porous. Some of the synthetic materials employed in Great Britain are of British manufacture; but practically the whole of the natural and treated minerals are imported from outside the Empire.

Of great interest are the exchange properties of synthetic resins, established during the past year at the Chemical Research Laboratory at Teddington. Those prepared from certain phenols and tannins possess marked base-exchange properties. Certain of these resins are highly selective in their action, but others are capable of removing as much calcium and magnesium from hard water as an equal weight of the commercial water-softening materials with the highest base-exchange values. Other resins prepared from aromatic bases, such as aniline, possess the property of removing anions or acidic radicals from solution. Thus by filtering sea-water, first by particles of a tannin resin and then through particles of an anilin resin, and repeating the operation several times, most of the salt content of the sea-water is removed.

The Board continues its policy of establishing methods of overcoming the difficulties raised by the waste materials discharged from manufacturing operations, either by direct investigation or in co-operation with other bodies. In this respect the waste from a milk factory is dealt with. An activated sludge can be worked up which will produce a fairly satisfactory effluent, but the sludge so produced is very sensitive to small changes, and great care is needed in its manipulation.

An alternative method which promises well consists in the filtration of the milk waste through two bacteria beds arranged in series. The first filter retains most of the milk solids and the second filter delivers a final effluent of excellent quality. In order to avoid choking of the filters by the milk solids the order of the filters is alternated, say, after a fortnight, so that the secondary filter becomes the primary filter and vice versa. This procedure ensures that the two classes of materials present in the milk—those in suspension and colloidal condition, as fats, proteins, etc., on one hand, and those in solution as milk sugar, etc., on the other hand—shall be brought into the same biochemical picture. The result is that the fatty matter is largely destroyed and the condition of the slimy solids altered to brown particles which will pass through the filter. The filter method has amongst other advantages that of considerable stability, and it lends itself in consequence better to the rough and tumble of works practice.

Another important trade waste of very general interest, namely, gas works effluents, is dealt with in this report; a brief review is given of the work being done towards the solution of the problem of disposing of these wastes in a satisfactory manner by the gas industry itself, working through the Institution of Gas Engineers.

Particular interest is attached to this work, as it furnishes an excellent example of a great industry applying itself to the disposal in an orderly manner of the residues from manufacturing operations when economic returns have become doubtful or even negative. This method of approach permits the question to be dealt with from every aspect, and often enough results, as in this case, in modifications of manufacturing practice with benefit to all concerned, and simplification of the problem finally presented by the discharge of the waste liquors to the public sewers.

The Institution of Gas Engineers carries on the work involved through its "Liquor Effluents and Ammonia Committee", and this work has been in progress for a number of years. The Water Pollution

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Research Board is represented by its director, Dr. H. T. Calvert, and its secretary, Dr. A. Parker, on this Committee, so that there is active co-operation in this important matter.

An immense amount of detailed work is dealt with each year by Dr. A. Key, the research chemist to the Liquor Effluents Committee. Besides possible modifications in gas works practice which have been previously indicated, the annual report of this Committee deals in great detail with the effects of spent liquor on one hand and crude or ammoniacal liquor on the other, when mixed with sewage in various proportions, and the resulting mixed liquors dealt with by standard methods of biological oxidation, such as the activated sludge process or filtration through bacteria beds. Broadly, it may be said that the former process is more sensitive than the latter, that the average proportion of gas liquor to sewage in a town varies from 0·3 to 0·5 per cent by volume, that if the waste liquor is discharged at a level rate to the public sewers no serious difficulty arises at a well-designed sewage purification plant so long as spent liquor only is discharged. On the other hand, crude or ammoniacal liquor from gas works introduces difficulties which are not associated with spent liquor; and as the Institution of Gas Engineers is pursuing quite promising investigations on the recovery of the ammonia from crude liquor, it is very desirable from every point of view that these efforts shall be successful.

The Water Pollution Research Board continues its detailed investigations on activated sludge in relation to its action on various types of sewage, and also on various materials such as sugars—fructose, maltose, glucose, etc., amino acids, fatty acids, fats, suspensions of proteins, and so on. Certain experiments were carried out showing that physical factors play an independent part in the action of the activated sludge process, etc.

The investigations which the Board has carried out on the River Tees, and the present survey which is being made on the estuary of the River Mersey, are of fascinating interest, and are providing not only a mass of information of scientific character, but also material facts affecting a wide range of interests, nautical, fishing, manufacturing, sanitary, etc. One fact elucidated seems to illustrate the complexity of the problems arising, when it is stated that on comparing the relatively unpolluted Lough Foyle with the heavily polluted Mersey: "Samples of the mud from the Lough contained larger proportions of organic matter than the samples from the bank near Stanlow in the Mersey".

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Mechanism of the Human Body

ODDLY enough, engineers have always enjoyed a thrill when shown the working mechanism of any bodily organ; the beating of an isolated heart taken from a tortoise, for example, arranged to circulate a suitable saline fluid, usually commands more admiration from an engineer than from a physiologist. It is not surprising, therefore, that the Institution of Mechanical Engineers should have invited a physiologist to deliver the Thomas Hawksley Lecture on November 29, and to present some of the more mechanical and physico-chemical processes taking place in the human body. Their selection, happily, fell upon Prof. A. V. Hill, Foulerton research professor of the Royal Society and a distinguished biophysicist.

The human body, as a whole, has often been likened to an internal combustion engine, for both ultimately depend on the transformation of chemical potential energy into heat and mechanical energy, and so the human body is as dependent on adequate food supply as is the engine on fuel. Dealing with the preservation and transport of food on sound engineering and biological lines, Prof. Hill stated that this is not enough, "for food must be supplied as well, and we are fools, if, on any moral, social, or political theory, we wilfully allow our population to remain below the level of health which science and engineering can provide". After dealing with problems common to physiology and engineering affecting deep diving, high flying, work at high temperatures and so on, he carried his hearers into the more intimate consideration of the processes occurring in two highly specialised tissues, muscle for the development of mechanical power, and nerve for high-speed conduction.

Prof. Hill described, with the authority of the leading experimenter in this branch, how the measurement of heat production in the various phases of muscle contraction have elucidated the energy transformations occurring; but he stated that "we need to know much more about the physical chemistry and the molecular structure of muscle before we can even begin to guess at the mechanism by which chemical energy is transformed directly into tension energy and mechanical work". Experiments on the mechanical efficiency of muscles give results dependent on the manner in which the muscles are employed: the mechanical efficiency in pedalling a bicycle, or in rowing a boat with sliding seat, under good conditions and not too fast, is about twenty per cent—perhaps twenty-five per cent as a maximum. Under most conditions, it is less, but it must be remembered that the accompanying heat dissipation serves the necessary purpose of maintaining body temperature. The power developed by a vigorous man in a steady condition of exercise may be as much as $\frac{2}{5}$ horse-power, while for maximum efforts of only a few seconds $1\frac{1}{2}$ horse-power may be attained.

During the consideration of the processes occurring in nerve, Prof. Hill dwelt on the difficult problem represented by the excitatory process in nerve. The application of radio-engineering to the problem has been productive in studying both electric excitation and the transmission of nerve impulses. When an electric current passes through a nerve from anode to cathode, a physico-chemical change occurs at the cathode which, if big enough, results in excitation. As soon as the current is broken, this cathode potential begins to disappear exponentially with time, proportionately to $e^{-t/k}$, where k is a time-constant