is, however, the prime factor, and the reason the sulphide particles float is because of the air-film attached to them and not because of oil buoyancy. Accordingly, though a small amount of oil is generally used, flotation may be, and in particular cases is, achieved without oil. Nor is it necessary to bring the mixture gently on to the water surface; the sulphide particles, if introduced below the surface, will attach themselves to air-bubbles introduced at the same time, and rise. This result is probably more readily completed if enough oil is present to cover the sulphides with the filmiest covering of oil, though an excess of oil would agglomerate such particles and cause them to sink. Be that as it may, it is considered that the particular function of the oil is to lower the surface tension of the water and so permit the mineral-laden bubbles to form a froth which is the stronger both because of the presence of the oil and because of the strengthening effect of the mineral particles themselves; in this latter connection the retention of the globular form by drops of water thrown on to a dusty floor is interesting. When thus assembled into a froth the collection of separated sulphides is easy.

Two main theories have been put forward to explain flotation. The first, and probably the most applicable, is that of interfacial tensions between the different phases, sulphide particle, air-bubble, water, and sometimes oil droplet. This was suggested by the difficulty of wetting sulphides. It is conceivable that the sulphide surface has a potentiality to oxidise or otherwise change its chemical state, and for that reason to stick to an air-bubble when brought in contact with one; whereas the oxides, carbonates, and silicates of the worthless material, having nothing to get from the air, are inert. Flotation may then for convenience be said to depend upon the surface energy of mineral particles, just as magnetic separation is dependent upon their magnetism.

The second theory, and one of great assistance as a working hypothesis, is based on the fact that mineral particles in water, by reason of the film around them, are electrically charged, the sulphide particles positively and the non-metalliferous particles and air-bubbles negatively. Under these conditions the attachment of the sulphide particles to the air-bubbles is readily understood; air being a non-conductor, discharge would not come with contact.

In addition to oil, sulphuric acid is also generally used. Its effect is to increase the wetting powers of the water, so that less of the waste is entrained with the sulphides and the concentrate consequently cleaner. Whether the view be taken that the acid achieves this effect simply by cleaning the surfaces, or by acting as an electrolyte, largely depends upon what theory is being applied. If carbonates be present in the ore, an additional effect of the acid is that the generation of carbonic acid gas may render the special introduction of air unnecessary, since experience has shown that bubbles of this gas may take the place of air.

Whatever the true theory, it is impossible to question the fact of the great importance of flotation concentration. Its success upon the zinc middling product at Broken Hill was immediate. At first, in 1900, used only for treating a sandy material, with the elimination of imperfections and the introduction of improvements it eventually became applied to the slime, the position now being that the whole range of zinc products on that field is treated by flotation, and zinc ore to the extent of about 500,000 tons per year is being recovered.

Such a success could not be without influence upon the recovery of fine material elsewhere, and at this time the large disseminated copper deposits of America were becoming big producers of copper. With these low-grade deposits ordinary gravity-concentration was yielding at most, even with an extensive plant, a 70 per cent. recovery of the contained copper, the larger part of the loss being in the very fine material. Upon this material flotation tests showed a much better recovery, and many plants have now been provided with a flotation equipment to treat this fine material, bringing the total recovery of the copper up to about 85 per cent. One large mine, having a capacity of several thousand tons a day, has indeed gone to the extent of making flotation the prime concentration process employed, in spite of the fact that a gravity-concentration plant had been designed and was about to be put into execution.

Lead ores in their turn have had this process applied to their finer material, to the much-improved recovery of the lead contents; while simple zinc ores have similarly benefited. Flotation has also in some cases been applied to the beneficiation of the fine sulphides of silver and the tellurides of gold, encroaching in these cases upon a field long the monopoly of the cyanide process; while among the ores of the minor metals, molybdenite, the sulphide of molybdenum, except for what can be done by hand-picking, is entirely recovered this way.

Finally, it may be said that though Australia led the way, there is scarcely a metalliferous district in the world where flotation has not become a factor of the greatest interest, while its advent has been to the base metals the same beneficent revolution that the cyanide process was to the precious metals.

It is a pleasure to know that this process, like the cyanide process, was largely the discovery of British experimentalists, and in connection with it the names of Elmore, Sulman, and others will become historical. The only regret is that it should have been the subject of so much litigation and the source of so much animosity.

## *MAJOR SYDNEY D. ROWLAND.*

WE regret to announce the death on March 6, in France, from cerebro-spinal fever, of Major Sydney Donville Rowland, R.A.M.C., M.R.C.S.

Sydney Rowland was born in 1872 and educated at Berkhamsted School, whence he proceeded in 1889 to Cambridge with a science scholarship at Downing College. At Cambridge he took the Natural Science Tripos and was for a short time assistant demonstrator in the Physiological School. Whilst at Cambridge he was a prominent member of the Cambridge Natural History Society and some time its president. At this time he was keenly interested in almost every department of natural science and philosophy. As a friend who was his contemporary has expressed it, he was an amateur of science in the best sense of that word.

After leaving Cambridge Rowland came to London and completed his medical studies at St. Bartholomew's Hospital. At the end of 1898 he received an appointment which afforded him scope for his particular gifts, namely, that of assistant bacteriologist at the Lister Institute, and he remained a member of its staff until his death. Henceforth he was able to devote the whole of his time to scientific investigation.

Rowland was an extraordinarily good mechanic, and his ingenuity and skill were at all times at the service of his colleagues. The conquest of technical difficulties was a pure joy to him, and he was even sometimes in danger of letting it assume the importance of an end in itself. He early became an excellent microscopist, and ultimately acquired an unusually perfect command of all the applications of what he used to term "glass and brass."

His earlier researches were concerned with the structure of bacteria and the study of various enzymes which Hedin and he discovered in the expressed juices of animal cells. The next important piece of work upon which he was engaged was carried out in conjunction with the late Dr. MacFadyen. The latter having ascertained that bacteria survived the temperature of liquid air, it occurred to him and Rowland that grinding up bacteria at this low temperature would afford a cell-juice much more nearly resembling the composition of living bacteria than had hitherto been possible to attain, and they hoped that the injection of bacterial cell-juices, so obtained, into animals might afford curative sera for typhoid and other diseases. The research was a lengthy one, and the technical difficulties to be overcome very considerable. The latter were ultimately conquered by Rowland, but the result was disappointing, and the main object was not attained.

Rowland was a member of the Commission for the Investigation of Plague in India and worked at Bombay during 1905 and 1906. He took an active part in establishing the dependence of the human epidemic of plague upon the rat epizootic and the importance of the rat flea in the spread of the disease.

On his return to England he worked upon problems in plague immunity, principally with a view to the improvement of methods of prophylactic inoculation, and published a number of important papers on this subject. He was still occupied in this work when, in October, 1914, he obtained a commission in the R.A.M.C. and proceeded to France in charge of No. 1 Mobile Laboratory. He was recently engaged in discovering meningococcus "carriers" amongst troops and contracted the disease himself.

Rowland had an original and versatile mind and was interested in almost all departments of scientific activity. He was somewhat erratic, but a faithful friend, whose spontaneous gaiety and generous sympathy endeared him to all those who knew him intimately.

C. J. M.

## NOTES.

It is officially announced that Mr. A. D. Hall has been appointed Permanent Secretary to the Board of Agriculture in succession to Sir Sydney Olivier, K.C.M.G., now resigned. Sir Sydney has made many friends at the various agricultural colleges and research institutions, and his term of office has been marked by a kindly and sympathetic consideration of all matters relating to the application of science to agriculture. He carries with him into a well-earned retirement the good wishes of all those with whom he was brought into contact. The agricultural teachers and advisers, and the workers at the agricultural institutions generally, greatly appreciated his sincerity and his obvious desire to help British agriculture in every way possible. During his term of office the Board of Agriculture has considerably expanded, and is now larger than ever before. Mr. Hall's appointment as Sir Sydney's successor will be welcomed everywhere, and will be taken as an earnest that still further developments are contemplated. Mr. Hall has recently put forward his ideas in his book, "Agriculture after the War," in which he sets out a coherent plan for the development of British agriculture on sound scientific lines. Several of the recommendations have since been adopted, and there can be little doubt that the war period will furnish experience of special measures which will be invaluable in the reconstruction after the war. Thus Mr. Hall starts in his new office at an opportune moment for further developments. At the same time it must be admitted that in many respects the situation is bad; some egregious blundering on the part of War Office officials in their dealings with agriculturists has recently come to light, and has caused serious misgivings among farmers. Mr. Hall has the hearty good wishes of everyone in the attempts he will doubtless make to straighten out the tangle.

When the establishment of a separate Department of Scientific and Industrial Research was announced in December last, Lord Crewe stated that the Chancellor of the Exchequer was prepared to advise the Government to devote a sufficient sum to cover operations during the next five years on a scale which would provide four, or perhaps five, times as much for co-operative industrial research as had been spent for the whole purposes of research hitherto. The Civil Service Estimates just issued include the sum of 1,038,050*l.* to the Department of Scientific and Industrial Research, being a net increase of 998,050*l.* upon last year's amount. Grants for investigations carried out by learned and scientific societies, etc., are estimated at 24,000*l.*, and grants to students and other persons engaged in research at 6000*l.* These grants will be distributed by a committee of the Privy Council, on the recommendation of the Advisory Council, to promote the development of scientific and industrial research in the United Kingdom, and will be subject to such conditions as the committee may