and potash, both singly and in combination, and some of their field experiments, the classical plots, have been continued at Rothamsted to the present day. Their pioneer work was followed by the use of increasing quantities of nitrogenous, phosphatic and potassic fertilizers in addition to the traditional organic manures. Supplies of phosphatic fertilizers presented no problem since there were known deposits of naturally occurring rock phosphate, and in 1861 the commencement of the working of potash salt deposits ensured a supply of potassic fertilizers. Not until forty to fifty years ago, however, when fixation of atmospheric nitrogen on an industrial scale became possible, could adequate supplies of nitrogenous fertilizers be assured.

Sir William directed attention to the recent rapid rise in fertilizer consumption in Britain, the need for fertilizers being accentuated by intensification of cropping and reduction in imports of animal feeding stuffs. A wide range of fertilizers is now provided by modern chemical industry. In addition to ammonium sulphate, superphosphate and basic slag, such nitrogenous and phosphatic fertilizers as liquid ammonia, ammonium nitrate, calcium nitrate, urea, nitrophosphate, triple superphosphate and silicophosphate are available. Supplies of potassic fertilizers are still directly dependent upon deposits of potash salts in various parts of the world. Other major plant nutrients, apart from nitrogen, phosphorus and potassium, include calcium, magnesium and sulphur, and the significance of these was referred to by Sir William; there are also the trace elements (iron, manganese, copper, zinc, boron, molybdenum and chlorine) which, when deficient in the soil, and in some cases when present in excess, are responsible for reduction in crop yield or for disease in both crops and stock.

The precise determination of the manurial requirements of crops is a matter of no little difficulty. Different soils of varying fertility vary in their response to fertilizer application, and that section of the lecture which Sir William devoted to soil testing makes it quite clear that soil fertility cannot be completely explained in chemical terms, since biological, physical and climatic factors are involved also. Total chemical analysis of soil reveals only the quantities of potentially available plant nutrients.

Arbitrary chemical methods for determining the amounts of phosphorus and potassium in the soil that are available to the plant, and the amount of lime necessary to correct soil acidity (the lime requirement), have been developed, and the results, correlated with those of field experiments, can be interpreted in terms of fertilizer application to crops. Nitrogenous manuring, however, still lacks a reliable method of soil analysis upon the results of which guidance can be given, and although field experimentation has provided many useful data, more precision is desirable.

The phenomenon of base exchange in soils and the nature of the clay and humus of soils are of first importance in crop nutrition. Sir William dealt briefly with the researches which have increased our knowledge in this connexion and directed attention to the practical application of the results of these researches. Sound manurial practice involves the maintenance of a suitable balance between the amounts of the various exchangeable cations, and a further application of the principle of base exchange is the use of gypsum in the reclamation of saline and

alkali soils in various parts of the world, and of soils flooded by sea water. By the release of exchangeable sodium ions from the soil colloids and their replacement with calcium ions, the deflocculation of the soil colloids is prevented and a favourable soil structure for plant growth ensured. New techniques applied to the study of clay and humus have revealed properties intimately concerned with the physical conditions of soils and with their capacity to take up and retain plant nutrients.

Lastly, Sir William discussed the relationship between organic manures and fertilizers, pointing out that in Britain half the food for crops still comes from farmyard manure, which also improves soil texture and enhances the capacity of the soil to retain water and plant nutrients. Fertilizers, however, are essential since farmyard manure may be deficient in necessary plant nutrients, and moreover, the amounts of organic manures available are not sufficient to meet the needs of present-day intensive farming. The contentions of those who are opposed to the use of fertilizers and who condemn all chemical aids to agriculture on the grounds that there is some vital principle present in organic manures which must be transmitted to the soil if crops, livestock and the human population are to remain healthy, are without scientific foundation. The alleged harmful effects of fertilizers existed before they were discovered and are rife where they have never been used.

This Dalton Lecture was a reminder that, besides his world-famed work in chemistry and atomic theory, John Dalton made notable scientific contributions to meteorology; all agricultural scientists concerned with the water requirements of crops owe to him the first clear ideas of the nature of the evaporation processes, and Dalton may be said to have laid the foundation for modern work in this field.

J. S. WILLCOX

OBITUARIES

Prof. W. M. H. Greaves, F.R.S.

W. M. H. GREAVES, Astronomer Royal for Scotland and professor of astronomy in the University of Edinburgh, who died suddenly on Christmas Eve at the age of fifty-eight, was one of that distinguished series of Cambridge men who have held the Isaac Newton Studentship. His published papers cover a wide range of astronomical subjects, from perturbation-theory to geomagnetism; but his principal interest was the use of photography for the study of the spectra, and especially the continuous spectra, of stars. His appointment as chief assistant at Greenwich, in 1924, gave him his initial opportunity in this field, and he seized and developed it with characteristic enthusiasm. The 30-in. reflector, mounted on the same assembly as the 26-in. refractor (to the great inconvenience of both), was all that was available for such work at the Royal Observatory of that day, but Greaves took such obstacles in his stride. The rather less obvious (but much more formidable) challenge presented by the Greenwich sky was met by rigorous adherence to well-considered rules for observing, and the small probable errors of the results which were obtained testify to the judgment, as well as the courage, which lay behind the whole programme. Six years after his arrival at Greenwich,

"gradients" were published for twenty-four stars "suitable for use as spectrophotometric standards", and these intercomparisons were of such quality that they scarcely had to be modified at all as a result of the main programme which followed. This comprised 250 stars, most of them fainter than the standard ones; but the foundations had now been laid, and the advent of the new 36-in. Yapp reflector in 1934 also speeded the work. By 1938, when Greaves was appointed to Edinburgh, there was little still to do except publish the extensive results.

An essential part of photographic spectrophotometry is the calibration of the plates, and since it would have been very time-consuming to use, in this, the long exposures which had to be used on stars, the question of 'reciprocity failure' had had to be faced. Greaves reduced this somewhat venerable bogey to very manageable proportions, and definitely established the value of photography as a precise quantitative tool, at a time when photocells were still too insensitive to compete in this field.

The Second World War came soon after his move to Edinburgh, and for a while his principal concern was with the time service, where he co-operated closely with the Greenwich station that had been evacuated to Abinger; a substantial share of the advance in accuracy which occurred about this time, in spite of difficult conditions, was due to him. After the War, he obtained for his Observatory a badly needed increase in staff, and spectrophotometric data both on the Sun and on early-type stars have come increasingly from Edinburgh in recent years. Extensive work is in progress that would undoubtedly have benefited further from his leadership if he had lived.

Greaves definitely enjoyed taking charge of things, and could keep a committee firmly to the point. He served for six years as secretary of the Royal Astronomical Society, and was president during 1947-49. He was an active member of several commissions of the International Astronomical Union, serving for seven years as president of the one for photometry. His influence in the British National Committee for Astronomy was considerable, and he was one of the keenest sponsors of the plan for a large paraboloid at Jodrell Bank.

He will be warmly remembered by those who have worked under him, and with him. His complete integrity, and his devotion to astronomy, were unquestionable; but his numerous generousities may often have been less commonly known. The proportion of his papers which bear also the names of one or more subordinates is high, and this reflects not only his scrupulous fairness but also his power of stimulating the best efforts of his staff in the first place. He was capable of brusqueness, and even more, on occasion; but those who could see past this will remember the very real tact and skill with which he would guide and help all, whether old subordinates or new colleagues, who were associated with him.

R. D'E. ATKINSON

Dr. F. H. Burstall

DR. F. H. BURSTALL, who died on December 2 at the untimely age of fifty-two, had spent the whole of his working life at Teddington. He was one of a small band who were recruited by the late Sir Gilbert Morgan to staff the Chemical Research Laboratory (of the Department of Scientific and Industrial Research) when it was founded in 1925; and it can

be said with truth that no one has done more to establish the prestige and repute that the Laboratory has, in the meantime, achieved.

The second son of the late Prof. F. W. Burstall (who held the chair of mechanical engineering and was dean of the Faculty of Science in the University of Birmingham), Francis Burstall did not follow the profession in which other members of his family have achieved distinction. After graduating at Birmingham with first-class honours in chemistry, he became research assistant to Morgan, who had been his professor and was about to take up a new appointment as superintendent of the Teddington Laboratory.

As a young man Burstall was entirely unsparing of the time and effort he applied to chemical research. He made substantial contributions to the organic chemistry of selenium and tellurium, undeterred by the frequently obnoxious nature of the materials he had to handle. It was, however, by his work on metallic co-ordination compounds that he won recognition as an authority in a field then little cultivated. In a book published in 1933, of which he was co-author with Morgan, he provided an admirable survey of the more recent developments in this branch of inorganic chemistry.

When war came in 1939, Burstall was obliged to take on a succession of problems which, important though they were at the time, offered little of continuing interest, and it was only with the ending of hostilities that his Department was able to make the best use of his very versatile ability. In 1947 he was placed in charge of a small section set up to study the analysis of uranium and thorium ores on behalf of the Department of Atomic Energy. The extraordinary value of the contribution that he and the staff he led (and inspired with some of his own enthusiasm) were able to make to the national effort in this new field was quickly recognized. Greater responsibilities were laid upon Burstall, and his unit ultimately became so large that an extensive new building was constructed and equipped to accommodate what now became the Radiochemical Group of the Chemical Research Laboratory. Those who knew what Burstall put into his task will always see in this fine laboratory a memorial to his success in what, unfortunately, was to be the last phase of his scientific career. Much must remain untold; nevertheless, the series of papers in which he and his colleagues revealed their application of chromatography to the separation of metals indicate the power and generality of a technique they were among the first to use. The formal seal was set on Burstall's accomplishments in chemical research when in 1952 he attained the academic distinction of D.Sc. of the University of London.

Modest and self-effacing, Burstall was nevertheless a man whose judgments were shrewd, being based on wide (if unparaded) knowledge and deep self-communion. He had an extraordinary charm for his friends and colleagues. This was due to the utter impossibility for him to do or say anything in the slightest degree unkind or inconsiderate. His main preoccupation throughout his life was with chemistry, which to him was far more than the means to a livelihood. To purely personal advancement he never gave a thought; nevertheless, he found a high degree of self-fulfilment as a scientist in the service to which he gave his loyalty and whose traditions he upheld.

In the course of his last illness he underwent two major operations and it almost seemed after the first that hope could be entertained of a recovery. Un-