low values encountered in the pyramidal tracts indicate that the upper motor neuron is not cholinergic. In the motor area of the cerebral cortex an intermediate value was found. This might suggest that cholinergic neurons converge on the pyramidal cells. Similarly, the low values found for the posterior roots and their central continuation, the funiculi gracilis and cuneatus, are in agreement with the conception that the first neuron of the afferent sensory pathway is non-cholinergic. However, the relatively high values obtained for the nuclear masses in which these sensory fibres end might be evidence for the cholinergic nature of the second neuron in the sensory pathway.

The third neuron, originating in the thalamus and leading to the cortex, is probably non-cholinergic, as suggested by the low values found for the fibres in the posterior parts of the internal capsule, which at least in man is said to contain the thalamic radiation. Another example was provided by the optic pathway. The retina contains large amounts of the enzyme which synthesizes acetylcholine, whereas the optic nerve is practically free from it. This suggests that acetylcholine is the chemical transmitter at one or more of the synaptic junctions in the retina. Among these junctions may be that to the ganglionic layer from which the non-cholinergic optic nerve originates. The optic fibres end mainly in the lateral geniculate body, and the high enzyme values found for this region may indicate a cholinergic nature of the third neuron in this pathway. Dr. Feldberg stressed the fact that, however attractive such a pattern of a succession of alternating non-cholinergic and cholinergic neurons may be, it would be dangerous to have a conception which is too simplified and diagrammatic. We must realize that if there are two different kinds of neurons in the central nervous system, then on purely statistical grounds there should be a great incidence of such an alternation.

The great number of problems involved in the process of central synaptic transmission and their complexity were brought to light by beautiful experiments on cockroaches reported by Mr. J. W. S. Pringle and Mr. G. M. Hughes. They had passed weak polarizing currents laterally through the metathoracic ganglion of the cockroach. This affected the flexor-extensor balance in such a way that the leg on the negative side flexed while that on the positive side extended. With longitudinal stimulation, ascending currents flexed the legs on both sides of the cockroach and descending currents encouraged extension. It is interesting that Skoglund had observed similar reaction patterns in corresponding experiments on cats. Mr. Pringle and Mr. Hughes suggest that the weak polarizing current excites internuncial fibres and not the motoneurons, because preparations in which only a single nerve was left attached to the ganglion did not show this differential effect when the polarizing current was applied between ganglion and nerve. In these preparations the negative electrode on the ganglion excited, and the positive inhibited, any resting discharge in the larger motor fibres, irrespective of whether the nerve supplied flexor or extensor muscles.

Concerning the problem of chemical transmission, they pointed out that the evidence available shows that the motor nerves to the muscles are not cholinergic in the Arthropoda. On the other hand, acetylcholine may well have a transmitter function at the central ganglionic synapses, because its application to these ganglia causes a discharge of impulses in the motor nerve fibres. It is further possible that the differential effect of polarizing current is due to the fact that in Arthropoda, as in other organisms, two types of transmitter substances are involved in central synaptic transmission.

At the end of the meeting, Prof. R. J. S. McDowall showed a few slides from his recent experiments on the rat's diaphragm preparation, in which he had obtained a curare-like block of neuromuscular transmission as an effect of lack of glucose.

OBITUARIES

Dr. William Cullen

By the death, at the age of eighty-one, of Dr. William Cullen, a prominent figure and a vivid personality has been lost to a wide circle of men actively engaged in the varied pursuits which are related directly and indirectly to chemical technology, to metalliferous mining and to metallurgy.

It would be difficult to enumerate the manifold activities with which his name has been identified over the past fifty years; but these are happily recorded, for the most part, in the numerous papers and addresses which he had contributed to the various scientific and technical bodies with which he was associated. His earlier work was published under the auspices of the Chemical, Metallurgical and Mining Society of South Africa, of which he became president in 1905. In later years, the *Transactions of the Institution of Mining and Metallurgy, the Institution of Chemical Engineers* and *the Society of Chemical Industry* have been enriched by his contributions. By each of these bodies in turn he was elected to the presidential chair.

Dr. Cullen's life-work can be divided into two periods. The first was that of his earlier work in South Africa, commencing with his appointment, in the later stages of the 1899–1902 War, as general works manager, at Modderfontein, of the British South African Explosives Co. While retaining his close association with South African affairs to the end, particularly in regard to educational matters, the second period of his career dates from the time of his return to Great Britain in 1915, when, in association with the late K. B. Quinan and W. McNab, he was entrusted by Lord Moulton (then directing the Department of Explosives Supply) with the design and lay-out of new explosives factories called for by the exigencies of the First World War.

A Scotsman, reared in the hard school of the west coast and the Clydeside, Cullen received his early training in Glasgow, successively at Hutcheson's Grammar School and at what was then the Andersonian College (now the Royal Technical College). As a chemist, he became a member of the staff of Nobel's and later of Kynochs. It was this early experience of the chemistry of explosives that fitted him for the very prominent part he was destined to play in the vast developments which occurred in the mining industry in South Africa following the termination of the War of 1899–1902. The necessity had already been recognized and to some extent met, for the independence from outside supplies of industrial explosives, and it fell to Cullen's lot to promote this independence in step with the growing and pressing demands.

In these surroundings Cullen found scope for his wider interests and inherent sympathies. The admirable spirit of co-operation, and the refreshing freedom from secrecy regarding experience and knowledge of technical matters, which he found to exist among those directing the mining industry were fully in accord with an outlook which may be regarded as one of his happiest characteristics. Two matters in particular caused him grave concern. First, the appalling mortality, at that time, among those engaged in underground mining, and secondly, the widespread neglect to provide technical training for the younger members of the community. To both these problems Cullen gave unremitting thought and attention, which persisted, in one form or another, to the end of his life.

As the direct outcome of his own responsibilities, Cullen sought for more precise information regarding the nature of the gases resulting from the explosives which, at that time, were in general use underground. The previous neglect of this aspect of blasting operations was attributed by Cullen to a lack of contact between the manufacturers and the users of explosives, but "there," he said in one of his addresses, "we lived next door to each other." The results of the investigations, with relatively crude appliances and despite the serious hazards which close sampling involved, shocked them all. Ready, as he always was, to face up to unpalatable facts, he pursued these investigations in collaboration with his colleagues, T. Donaldson, E. Weiskopf and W. Waters. Discussions, following the publication of their results, lasted many months. Public conscience was aroused, and the Government took note. A commission was appointed (at which Cullen was an important witness) and the matter was followed by further work.

Although these inquiries did not attempt to go to the root causes of silicosis, as subsequent work has done, they, nevertheless, did much towards eliminating the hazards of poisoning from carbon monoxide and the oxides of nitrogen by establishing on a firm basis the need of an 'oxygen balance' in regard to all explosives used underground. Cognizance of this important requirement was taken all over the world. At the same time, Cullen was not unmindful of the unsolved problems of ventilation in mines; and the stimulus thus given to the need for greater attention to this matter has helped towards the immense advances which have now been made in this direction.

In regard to education and training, both in South Africa and in Great Britain, Cullen lived to see many of his cherished hopes and aspirations realized. As a member of the original Transvaal Council of Education and as an active participant in the work of the Transvaal Technical Institute, he helped to pave the way for the foundation of the University of the Witwatersrand. Recognition of these services was made in 1925, when the University conferred upon him the honorary degree of LL.D. He continued to represent the interests of the University in Great Britain. Of many ways in which he sought to promote its welfare, perhaps the outstanding service was the part he played, under the chairmanship of the Earl of Athlone, in making good, so far as possible, the losses sustained by the Library of the University as the result of the disastrous fire on Christmas Eve of 1931.

In addition to his unremitting services on the councils of those institutions and technical bodies over which he had in turn presided and of which he was later elected to honorary membership, he was an indefatigable lecturer and speaker on matters which came within his wide experience. As recently as 1944 he was called upon to preside over the deliberations of the Science Masters' Association.

Such were the activities of a man of far-seeing vision and buoyant disposition with a unique experience of men and affairs, one who has left a mark on generations of chemical technologists, mining engineers and metallurgists, and one to whom they could look with confidence at all times for guidance, encouragement and enduring friendship.

S. W. Smith

Sir Thomas Crozier

Major Sir Thomas Henry Crozier, formerly His Majesty's Chief Inspector of Explosives at the Home Office, died at Folkestone on September 26 at the age of eighty. Born at Monkstown, County Dublin, on February 26, 1868, he was educated at the United Services College, Westward Ho, and the Royal Military Academy, Woolwich, and was gazetted to the Royal Artillery in 1888. He held the posts of chief instructor in ammunition and explosives at the Ordnance College and afterwards chief instructor in artillery at the Royal Military Academy. He retired from the Army on April 17, 1908, when he was appointed one of His Majesty's inspectors of explosives at the Home Office.

On October 5, 1914, he rejoined the Army and served in "A" Battery of the 58th Brigade, Royal Field Artillery, 11th Division, Mediterranean Expeditionary Force. He was eventually invalided, and on recovery and after urgent representations by the Home Office owing to the greatly increased pressure of work, he rejoined the Explosives Department of the Home Office in October 1915. On February 12, 1926, he was appointed His Majesty's chief inspector of explosives. His work was rewarded on June 3, 1930, by the conferment of a knighthood. He retired on March 30, 1931.

During Sir Thomas's term of office in the Explosives Department, low-freezing explosives were introduced into general use in Great Britain, and the Petroleum Act, 1926, and the Petroleum (Consolidation) Act, 1928, were passed. Regulations were made for the conveyance by road of petroleum spirit, carbon disulphide and for the 'permanent' gases compressed in a metal cylinder. He was associated with a number of committees dealing with petroleum, dissolved acetylene, fire extinguishers, permitted explosives, classification of explosives used by the Fighting Services, carriage of dangerous goods in ships, welded containers, and cylinders for permanent and liquefiable gases. During the years 1927 and 1928, in conjunction with the late Prof. J. S. S. Brame, he carried out, on behalf of the Minister of Transport, a public inquiry into the modifications of the petroleum spirit by-laws proposed to be made by the Port of London Authority.

During the Second World War, the work of the Explosives Department increased considerably and, in consequence, Sir Thomas Crozier was asked to rejoin the Department, which he did on June 1, 1940. He relinquished this temporary appointment on September 30, 1944, owing to ill-health.