flammable portion of the dynamite to the temperature necessary for the sudden transformation of the nitro-glycerine into gas, and will thus bring about the detonation of a portion of the cartridge, which will act as the initiative detonator to the remainder of the dynamite. On igniting separately, at one of their extremities, some dynamite cartridges which had been buried in snow for a considerable period, the lecturer has observed that, as the frozen material gradually burned away, very slight but sharp explosions (like the snapping of a small percussion cap on a gun nipple) occurred from time to time, portions of the frozen dynamite being scattered with some violence. It has come to his knowledge that small heaps of hard-frozen cartridges weighing altogether one pound have been detonated by igniting one cartridge which was surrounded by the remainder. These facts appear to substantiate the correctness of the foregoing explanation. They point to the danger of assuming that, because dynamite in the frozen state is less sensitive to the effects of a blow or initiative detonation, than the thawed material, it may therefore be submitted without special care to the action of heat, for the purpose of thawing it. Instances of the detonation, with disastrous results, of even single cartridges of frozen dynamite, through the incautious application of considerable heat (as for example by placing them in an oven, or close to a fire), have been, and are still, of not unfrequent occurrence, even though Mr. Nobel has insisted upon the application of heat through the agency only of warm water, as the sole reliable method of safely thawing dynamite cartridges.

While the sensitiveness to detonation of air-dry gun-cotton remains unaffected by great reduction in temperature of the mass, and while in this respect it presents advantages over nitro-glycerine preparations, wet gun-cotton becomes very decidedly more susceptible to detonation when frozen. Thus the detonation of gun-cotton containing an addition of from 10 to 12 per cent. of water is somewhat uncertain with the employment of 100 grains of strongly confined fulminate, and 200 grains are required for the detonation of the substance when containing 15 to 17 per cent. of water; but the latter in a frozen state can be detonated by means of thirty grains of fulminate, and fifteen grains are just upon the margin of the amount requisite for detonating, with certainty, frozen gun-cotton containing 10 to 12 per cent. of water.

The effects produced and products formed by the explosion of gun-cotton in perfectly closed spaces, both in the loose, and the compressed form, and by its detonation in the dry and the wet state, have been made the subject of study by Capt. Noble and Mr. Abel, the method of research pursued being the same as that followed in their published researches on fired gunpowder; results of considerable interest in regard to the heat of explosion; the pressures developed, and the products of explosion of dry and wet gun-cotton, have been obtained, which are about to be communicated to the Royal Society.

It may briefly be stated that the temperature of explosion of gun-cotton is more than double that of gunpowder (being about 4,400° C.); that the tension of the products of explosion, assuming the material to fill entirely the space in which it is fired, is considerably more than double that of the powder-products under the same conditions; that the products obtained by the explosion of dry gun-cotton are comparatively simple and very uniform under different conditions as regards pressure; that the products of *detonation* of *dry* gun-cotton do not differ materially from those of its explosion in a confined space, but that those furnished by the detonation of *wet* gun-cotton present some interesting points of difference. Messrs. Nobel and Abel are extending their investigations to the nitro-glycerine preparations.

The great advance which has been made within the last twelve years in our knowledge of the conditions which determine the character of the metamorphosis that explosive substances undergo, and which develop or control the violence of their action, finds its parallel in the progress which has been made in the production, perfection, and application of the two most prominent of modern explosive agents, nitro-glycerine and gun-cotton. Discovered at nearly the same time, less than forty years ago, the one speedily attained great prominence, on account of the apparent ease with which it could be prepared and put to practical use; a prominence short-lived, however, because the first, and somewhat rash, attempts to utilise it preceded the acquisition of sound and sufficient knowledge of its nature and properties. Even many years afterwards, when the difficulties attending its employment appeared to have been surmounted, the confidence of its most indefatigable partisans and staunchest friends received a rude shock, from which it needed the support of much faith and some fortitude to recover.

Meanwhile, the other substance, which now shares with it the honours of important victories won over gunpowder, continued to be generally regarded as a dangerous chemical curiosity, even for some time after its present position as one of the most important industrial products and useful explosive agents was being gradually but firmly secured for it, step by step, by the talent and untiring energy of a single individual.

Almost from the day of its discovery, the fortunes of gun-cotton continued to fluctuate, and much adversity marked its career, until at last its properties became well understood, and its position as a most formidable explosive agent, applicable on a large scale, with ease, great simplicity, and with a degree of safety far greater than that as yet possessed by any other substance of this class, has now become thoroughly established. Since the lecturer last discoursed on the properties of gun-cotton, seven years ago, this material has attained a firm footing as one of the most formidable agents of defence and offence. For all military engineering operations, and for employment in submarine mines and torpedoes, compressed gun-cotton, stored and used in the wet condition, has become the accepted explosive agent in Great Britain; within the last five years upwards of 550 tons have been manufactured for this purpose, and are distributed over our chief naval stations at home and abroad. Germany some years since copied our system of manufacture and use of gun-cotton; France has provided itself with a large supply for the same purposes, and Austria, where the acquisition of bitter experience of the uncertainty of gun-cotton in the earlier stages of history, naturally gave rise to a persistent scepticism regarding its present trustworthiness, appears now also about to adopt wet gun-cotton for military and naval uses.

But while the usefulness and great value of compressed gun-cotton in these important directions have been established, its technical application has made but slow progress as compared with that of the simple nitro-glycerine preparation known as dynamite, which, in point of cost of production and convenience for general blasting purposes, can claim superiority over compressed gun-cotton. Already in 1867 a number of dynamite factories, working under Nobel's supervision, existed in different countries; in that year the total quantity manufactured amounted to 11 tons; in another year the produce had risen to 78 tons; in 1872 it had attained to 1,350 tons. Two years afterwards the total production of dynamite was nearly trebled, and in 1878 it amounted to 6,140 tons.

There are as many as fifteen factories in different parts of the world (including a very extensive one in Scotland) working under the supervision of Mr. Nobel, the originator of the nitro-glycerine industry, and some six or seven other establishments exist where dynamite or preparations of very similar character are also manufactured.

How far the rate of production of dynamite will be affected by the further development of the value of Nobel's new preparation, the blasting gelatine, it is difficult to foresee, but there appears great prospect of an important future for this very peculiar and interesting detonating agent.

It is hoped that the subjects dealt with in this discourse afford interesting illustration of the intimate connection of scientific research with important practical achievements.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

DR. CARPENTER, Registrar of the University of London, announced his retirement from that office at the annual meeting of Convocation on Tuesday. A unanimous vote was passed, recognising his long and valuable services in the post which he had so long held.

THE recent retirement of Prof. Balfour from the Chair of Botany at Edinburgh has given rise to two changes in the Scottish professoriate. As his successor, our readers know, the Curators have appointed Dr. Alexander Dickson, the able Professor of Botany in the University of Glasgow. The botanical class has always been popular at Edinburgh, Dr. Balfour's students having recently numbered, we believe, upwards of 350. The class-room of the new professor, also, is so crowded that many of the auditors can hardly find standing-room, large numbers having been unable even to gain admission. Prof. Dickson is therefore under the necessity of lecturing twice a day. His retirement from Glasgow College has opened the way for a young botanist of great promise, Dr. I. Bayley Balfour, son of the veteran professor at Edinburgh, who has been appointed by the Crown to the vacant chair. Dr. Balfour took the degree of Doctor of Science in Botany some years ago with great distinction at Edinburgh. He was selected by the Council of the Royal Society to accompany the recent Transit of Venus Expedition to Rodriguez for the purpose of making a scientific examination of that island. As the result of his researches, besides the report on the natural history, which he has sent in to the Royal Society, he has produced an excellent paper on the genus *Halophila*. Having had considerable experience in class-work under his father, as well as under Professors Huxley and Sir Wyville Thomson, he enters on his new duties with many advantages. Whether as an original investigator or as a successful teacher, he will, we doubt not, fully sustain the reputation of the Glasgow University.

WE are glad to notice that the School Board for London have decided that it would be expedient to include the elements of natural science among the recognised subjects of class examination. The object of this resolution is to transfer what is called elementary science from the category of specific subjects into the category of class subjects. At present there is little inducement for pupils to take science subjects, nor will there be until it be included in the regular course of instruction in elementary schools. We hope the memorial which the Board is to prepare will be treated with the attention it deserves.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, May 8.—" On the Sensitive State of Electrial Discharges through Rarefied Gases." By William Spottiswoode, P.R.S., and S. Fletcher Moulton, late Fellow of Christ's College, Cambridge.

It has frequently been remarked that the luminous column produced by electric discharges in vacuum tubes sometimes displays great sensitiveness on the approach of the finger, or other conductor, to the tube. This is notably the case when with an induction coil a very rapid break is used, or when with any constant source of electricity an air-spark is interposed in the circuit leading to the tube. The striking character of the phenomena, and the opportunity which they showed for affecting the discharge from the outside during its passage, led the authors of this paper to consider that a special examination of this sensitive state would be desirable.

All the circumstances under which sensitiveness is produced appear to agree in requiring, first, that there should be a rapid intermittance in the current leading to the tube; and secondly, that the individual intermittent discharges should be small in quantity and extremely brief, if not instantaneous, in duration. Both these requirements are fulfilled by the methods used in the present investigation, viz., a Holtz machine with a suitable air-spark between the machine and the tube, and a small coil with a rapid break.

If a conductor be made to approach a tube conveying a sensitive discharge, due to an air-spark in the positive branch of the circuit, a series of effects is produced, of which the feeblest and the strongest are the most pronounced. The transition from one to the other is so rapid that the intermediate phases may be easily overlooked. In the first case, the luminous column is repelled by the conductor; in the second it is broken into two parts which stretch out in two tongues towards the point on the tube (P) nearest the conductor, while a negative halo appears between them.

That these effects are due to the inductive action of the conductor, or more particularly to re-distributions of electricity in it, co-periodic with the air-spark, and not to any permanent charge, is shown by the following experiments. A non-conductor, whether charged or not, is without effect. The effect of a conductor increases with its size or capacity, and with its proximity to the tube, until the fullest effect (viz., that given by an earth connexion) is produced. That the effects are not due to electro-dynamic, or to magnetic action, is shown by the fact that a coil of wire produces the same result, whether the ends be joined or not. The effects of an iron core and helix with open ends are often comparable with, and sometimes equal to, those when the ends, being connected with a battery, the whole becomes an electro-magnet. The effect upon the interior is, in fact, due to the relief given by the conductor to the electric tension on the outer surface of the tube and the space around it, caused by the individual discharges.

Instead, however, of connecting a point (P) on the tube with a large conductor or with earth, we may connect it with one or other terminal of the tube. And a further study of the subject shows that all the phenomena due to action from without may be produced by means of one or other of these connexions. Connexion with the non-air-spark terminal gives the relief effects described above; connexion with the air-spark terminal gives another set of effects. Of these the feeblest has the appearance of attraction, while the strongest shows an abrupt termination of the positive column in the neighbourhood of the point (P), followed by a negative halo, and then by a recommencement of the positive column in the direction of the negative terminal. Each of these sectional discharges is in fact independent and complete in itself, and they are due to impulses of positive electricity thrown into the tube from the air-spark. At the positive terminal these impulses are thrown directly in; at the points of connexion they are due to induction, *ab extra*. The negative part of what was originally neutral meets the positive column, and satisfies it as it arrives, while the positive leaps forward to meet the negative due from the negative terminal.

The effects above described need not be confined to a single patch or ring of conducting material placed upon the tube; but they may be produced many times over in the same tube by a series of rings arranged at suitable distances. By this means the column may be broken into a series of sections, all terminating with well-defined configurations towards the negative end, and having greater or less length, according to the position of the rings. In the paper itself, arguments are there brought forward showing that these sectional discharges represent striæ not merely in their appearance, but also in their function and structure. But the discussion could hardly be produced within the limits of an abstract.

Returning from the digression about striæ, the authors next give evidence, derived mainly from the revolving mirror, and from the discharges of a partially charged Leyden jar, for the following conclusion: That the passage of the discharge occupies a time sufficiently short in comparison with the interval between the discharges to prevent any interference between successive pulses. Certain experiments are then described which indicate that the discharge is effected, under ordinary circumstances, by the passage through the tube from the air-spark terminal of free electricity, of the same name as the electricity at that terminal. In the case of an induction coil, where the air-spark must be considered as existing at both terminals, there is evidence of a *neutral zone*, where the sensitiveness disappears. The position of this zone may be altered by damping the impulses at either terminal; or it may be abolished by connecting one terminal with earth. The impulses may even be so distributed as to divide electrically a single tube into three sections, the two extremes presenting visible discharges, with a dark section between them.

Looking at all these phenomena from an opposite point of view, we may, by means of the relief effects, determine the terminal from which a discharge proceeds, and the distance to which it reaches without provoking a response from the other. And through these considerations, together with others detailed in the paper, the authors are led to the conclusion that the discharges at the two terminals of a tube are in the main independent, and that they are each determined primarily by the conditions at their own terminal, and only in a secondary degree by those at the opposite terminal.

In illustration of this view, an account is then given of the production of unipolar, positive, or negative discharges in a tube. In such cases, the discharge being insufficient of itself to pass through the tube, returns by the way by which it entered.

This closes a series of experiments, the result of which is that the discharges from the two terminals can be made of equal intensity, or of any required degree of inequality; or the discharge can be made to issue from one terminal only, the other acting only receptively; or it can be made to return into its own terminal, while the other takes no part in the discharge; or, finally, the two terminals can be made to pour out independent discharges of the same name, each of which returns to its own terminal.

Having traced the relation between the two parts of the discharge, and having found means for controlling their range and influence, the authors were led to inquire whether there be any experimental evidence of the state of the tube during the occurrence of the discharge. Some experiments with two pieces of