College.	Grant, 1906-7. £	Proposed Grant. £
Victoria University of Manchester	12,000	10,000
University of Liverpool	10,000	10,000
University College, London	10,000	10,000
University of Birmingham	9,000	9,000
University of Leeds	8,000	8,000
King's College, London	7,800	7,800
Armstrong College, Newcastle-on-Tyne...	6,000	6,000
University College, Nottingham	5,800	5,000
University of Sheffield	4,600	5,000
Bedford College for Women, London ...	4,000	4,000
University College, Bristol	4,000	4,000
University College, Reading	3,400	3,400
Hartley University College, Southampton	3,400	2,250
London School of Economics	—	500

The report gives the committee's reasons for the diminution of the grant in the case of Manchester, Nottingham, and Southampton, and for the grant to the London School of Economics.

After a consideration of the reports of the inspectors who visited the institutions and of the statistics provided by them, the committee decided not to recommend a grant in the case of the Birkbeck College, the East London College, and the Royal Albert Memorial College, Exeter.

The grants enumerated in the table above amount to 84,950*l.*, leaving, if the grant of 1000*l.* to Dundee University College is continued, a balance of 14,050*l.* available for grants for special purposes.

THE BRITISH ASSOCIATION.

SECTION G.

ENGINEERING.

OPENING ADDRESS BY SILVANUS P. THOMPSON, D.Sc., F.R.S., PAST PRESIDENT OF THE INSTITUTION OF ELECTRICAL ENGINEERS, PRESIDENT OF THE SECTION.

IT would be impossible for any assembly of engineers to meet in annual gathering at the present time without reference to the severe loss which the profession has so recently sustained by the death of Sir Benjamin Baker. Born in 1840, he had attained while still a comparatively young man to a position in the front rank of constructive engineers. His contributions to science cover a considerable range, but were chiefly concerned with the strength of materials, into which he made valuable investigations, and with engineering structures generally. His name will doubtless be chiefly associated with the building of great bridges, to the theory of which he contributed an important memoir entitled "A Theoretical Investigation into the Most Advantageous System of Constructing Bridges of Great Span." In this work he set forth the theory of the cantilever bridge. Upon the plan there laid down he built the Forth Bridge, besides many other large bridges in various parts of the world. With that memorable structure, completed in 1890, his name will ever be associated; but he will be remembered henceforth also as the engineer who was responsible for the great dam across the Nile at Assouan, a work which promises to have an influence for all time upon the fortunes of Egypt and upon the prosperity of its population. Sir Benjamin Baker was, moreover, closely associated with the internal railways of London, both in the early days of the Metropolitan Railway and in the later developments of the deep-level tubes. He was elected a Fellow of the Royal Society in 1890, became President of the Institution of Civil Engineers in 1895, and was a member of Council of the Institution of Mechanical Engineers, besides being an active member of the Royal Institution and of the British Association. He was also a member of the Council of the Royal Society at the time of his death.

He enjoyed many honorary distinctions, including degrees conferred by the Universities of Cambridge and Edinburgh. In 1890 there was conferred upon him the title of K.C.M.G., and in 1902 that of K.C.B.

He had but just returned from Egypt, whither he had gone in connection with the project for raising the height of the Assouan dam, so as to increase its storage to more than double the present volume, when he died very suddenly on May 19, in his sixty-seventh year.

The Development of Engineering and its Foundation on Science.

We live in an age when the development of the material resources of civilisation is progressing in a ratio without parallel. International commerce spreads apace. Ocean transport is demanding greater facilities. Steamships of vaster size and swifter speed than any heretofore in use are being built every year. Not only are railways extending in all outlying parts of the world, but at home, where the territory is already everywhere intersected with lines, larger and heavier locomotives are being used, and longer runs without stopping are being made by our express trains. The horsed cars on our tramways are now being mostly superseded by larger cars, electrically propelled and travelling with greatly increased speeds. For the handling of the ever-increasing passenger traffic in our great cities electric propulsion has shown itself a necessity of the time; witness the electric railways in Liverpool and the network of electrically worked tube railways throughout London. In ten years the manufacture of automobile carriages of all sorts has sprung up into a great industry. Every year sees a greater demand for the raw materials and products, out of which the manufacturer will in turn produce the articles demanded by our complex modern life. We live and work in larger buildings; we make more use of mechanical appliances; we travel more, and our travelling is more expeditious than formerly; and not we alone but all the progressive nations. The world uses more steel, more copper, more aluminium, more paper; therefore requires more coal, more petroleum, more timber, more ores, more machinery for the getting and working of them, more trains and steamships for their transport. It requires machines that will work faster or more cheaply than the old ones to meet the increasing demands of manufacture; new fabrics; new dyes; even new foods; new and more powerful means of illumination; new methods of speaking to the ends of the earth.

We must not delude ourselves with imagining that the happiness and welfare of mankind depend only on its material advancement; or that moral, intellectual, and spiritual forces are not in the ultimate resort of greater moment. But if the inquiry be propounded what it is that has made possible this amazing material progress, there is but one answer that can be given—science. Chemistry, physics, mechanics, mathematics, it is these that have given to man the possibility of organising this tremendous development. And the great profession which has been most potent in applying these branches of science to wield the energies of Nature and direct them to the service of man has been that of the engineer. Without the engineer how little of all this activity could there have been; and without mathematics, mechanics, physics, and chemistry, where was the engineer?

If looking over this England of Edward the Seventh we try to put ourselves back into the England of Edward the Sixth—or for that matter of any pre-Victorian monarch—we must admit that the differences to be found in the social and industrial conditions around us are due not in any appreciable degree to any changes in politics, philosophy, religion, or law, but to science and its applications. If we look abroad, and contrast the Germany of Wilhelm the Second with the Germany of Charles the Fifth, we shall come to the like conclusion. So also in Italy, in Switzerland, in every one indeed of the progressive nations. And it is precisely in the stagnant nations, such as Spain, or Servia, where the cultivation of science has scarcely begun, that the social conditions remain in the backward state of the Middle Ages.

Interaction of Abstract Science and its Applications.

In engineering, above all other branches of human effort, we are able to trace the close interaction between abstract science and its practical applications. Often as the connection between pure science and its applications has been emphasised in addresses upon engineering, the emphasis has almost always been laid upon the influence of the abstract upon the concrete. We are all familiar with the doctrine that the progress of science ought to be an end in itself, that scientific research ought to be pursued without regard to its immediate applications, that the importance of a discovery must not be measured by its apparent utility at the moment. We are assured that research in pure science is bound to work itself out in due time into technical applications of utility, and that the pioneer ought not to pause in his quest to work out potential industrial developments. We are invited to consider the example of the immortal Faraday, who deliberately abstained from busying himself with marketable inventions arising out of his discoveries, excusing himself on the ground that he had no time to spare for money-making. It is equally true, and equally to the point, that Faraday, when he had established a new fact or a new physical relation, ceased from busying himself with it and pronounced that it was now ready to be handed over to the mathematicians. But, admitting all these commonplaces as to the value of abstract science in itself and for its own sake, admitting also the proposition that sooner or later the practical applications are bound to follow on upon the discovery, it yet remains true that in this thing the temperament of the discoverer counts for something. There are scientific investigators who cannot pursue their work if troubled by the question of ulterior applications; there are others no less truly scientific who simply cannot work without the definiteness of aim that is given by a practical problem awaiting solution. There are Willanses as well as Regnaults; there are Whitworths as well as Poissons. The world needs both types of investigator; and it needs, too, yet another type of pioneer—namely, the man who, making no claim to original discovery, by patient application and intelligent skill turns to industrial fruitfulness the results already attained in abstract discovery.

There is, however, another aspect of the relation between pure and applied science, the significance of which has not been hitherto so much emphasised, but yet is none the less real—the reaction upon science and upon scientific discovery of the industrial applications. For while pure science breeds useful inventions, it is none the less true that the industrial development of useful inventions fosters the progress of pure science. No one who is conversant with the history, for example, of optics can doubt that the invention of the telescope and the desire to perfect it were the principal factors in the outburst of optical science which we associate with the names of Newton, Huygens, and Euler. The practical application, which we know was in the minds of each of these men, must surely have been the impelling motive that caused them to concentrate on abstract optics their great and exceptional powers of thought. It was in the quest—the hopeless quest—of the philosopher's stone and the elixir of life that the foundations of the science of chemistry were laid. The invention of the art of photography has given immense assistance to sciences as widely apart as meteorology, ethnology, astronomy, zoology, and spectroscopy. Of the laws of heat men were profoundly ignorant until the invention of the steam engine compelled scientific investigation; and the new science of thermodynamics was born. Had there been no industrial development of the steam engine, is it at all likely that the world would ever have been enriched with the scientific researches of Rankine, Joule, Regnault, Hirn, or James Thomson? The magnet had been known for centuries, yet the study of it was utterly neglected until the application of it in the mariners' compass gave the incentive for research.

The history of electric telegraphy furnishes a very striking example of this reflex influence of industrial applications. The discovery of the electric current by Volta and the investigation of its properties appear to have been stimulated by the medical properties attributed in the preceding fifty years to electric discharges. But, once the current had been discovered, a new incentive arose in the dim possibility it suggested of transmitting signals to a distance. This was certainly a possibility, even when only the chemical effects of the current had yet been found out. Not, however, until the magnetic effects of the current had been discovered and investigated did telegraphy assume commercial shape at the hands of Cooke and Wheatstone in England and of Morse and Vail in America. Let us admit freely that these men were inventors rather than discoverers: exploiters of research rather than pioneers. They built upon the foundations laid by Volta, Oersted, Sturgeon, Henry, and a host of less famous workers. But no sooner had the telegraph become of industrial importance, with telegraph lines erected on land and submarine cables laid in the sea, than fresh investigations were found necessary; new and delicate instruments must be devised; means of accurate measurement heretofore undreamed of must be found; standards for the comparison of electrical quantities must be created; and the laws governing the operations of electrical systems and apparatus must be investigated and formulated in appropriate mathematical expressions. And so, perforce, as the inevitable consequence of the growth of the telegraph industry, and mainly at the hands of those interested in submarine telegraphy, there came about the system of electrical and electromagnetic units, based on the early magnetic work of Gauss and Weber, developed further by Lord Kelvin, by Bright and Clark, and last but not least by Clerk Maxwell. Had there been no telegraph industry to force electrical measurement and electrical theory to the front, where would Clerk Maxwell's work have been? He would probably have given his unique powers to the study of optics or geometry; his electromagnetic theory of light would never have leapt into his brain; he would never have propounded the existence of electric waves in the ether. And then we should never have had the far-reaching investigations of Heinrich Hertz; nor would the British Association at Oxford in 1894 have witnessed the demonstration of wireless telegraphy by Sir Oliver Lodge. A remark of Lord Rayleigh's may here be recalled, that the invention of the telephone had probably done more than anything else to make electricians understand the principle of self-induction.

In considering this reflex influence of the industrial applications upon the progress of pure science it is of some significance to note that for the most part this influence is entirely helpful. There may be sporadic cases where industrial conditions tend temporarily to check progress by imposing persistence of a particular type of machine or appliance; but the general trend is always to help to new developments. The reaction aids the action; the law that is true enough in inorganic conservative systems, that reaction opposes the action, ceases here to be applicable, as indeed it ceases to be applicable in a vast number of organic phenomena. It is the very instability thereby introduced which is the essential of progress. The growing organism acts on its environment, and the change in the environment reacts on the organism—not in such a way as to oppose the growth, but so as to promote it. So is it with the development of pure science and its practical applications.

In further illustration of this principle one might refer to the immense effect which the engineering use of steel has had upon the study of the chemistry of the alloys. And the study of the alloys has in turn led to the recent development of metallography. It would even seem that through the study of the intimate structure of metals, prompted by the needs of engineers, we are within measurable distance of arriving at a knowledge of the secret of crystallogenesis. Everything points to the probability of a very great and rapid advance in that fascinating branch of pure science at no distant date.

History of the Development of Electric Motive Power.

There is, however, one last example of the interaction of science and industry which may claim closer attention. In the history of the development of the electric motor one finds abundant illustration of both aspects of that interaction.

We go back to the year 1821, when Faraday, after studying the phenomena of electromagnetic deflexion of a needle by an electric current (Oersted's discovery), first succeeded in producing continuous rotations by electromagnetic means. In his simple apparatus a piece of suspended copper wire, carrying a current from a small battery, and dipping at its lower end into a cup of mercury, rotated continuously around the pole of a short bar-magnet of steel placed upright in the cup. In another variety of this experiment the magnet rotated around the central wire, which was fixed. These pieces of apparatus were the merest toys, incapable of doing any useful work;

nevertheless they demonstrated the essential principle, and suggested further possibilities. Two years later, Barlow, using a star-wheel of copper, pivoted so that the lowest point of the star should make contact with a small pool of mercury, found that the star-wheel rotated if a current was sent through the arm of the star while the arm itself was situated between the poles of a steel horseshoe-magnet. Shortly afterwards Sturgeon improved the apparatus by substituting a copper disc for the star-wheel. The action was the same. A conductor, carrying an electric current, if placed in a magnetic field, is found to experience a mechanical drag, which is neither an attraction nor a repulsion, but a lateral force tending to move it at right angles to the direction of flow of the current and at right angles to the direction of the lines of the magnetic field in which it is situated. Still this was a toy. Two years later came the announcement by Sturgeon of the invention of the soft-iron electromagnet, one of the most momentous of all inventions, since upon it practically the whole of the constructive part of electrical engineering is based. For the first time mankind was furnished with a magnet the attractive power of which could be increased absolutely indefinitely by the mere expenditure of sufficient capital upon the iron core and its surrounding copper coils, and the provision of a sufficiently powerful source of electric current to excite the magnetisation. Furthermore the magnet was under control, and could be made to attract or to cease to attract at will by merely switching the current on or off; and, lastly, this could be accomplished from a distance, even from great distances away. How slowly the importance of this discovery was recognised is now a matter for astonishment. To state that Sturgeon died in poverty twenty-six years later is sufficient to indicate his place among the unrequited pioneers of whom the world is not worthy. Six years elapsed, and then there came a flood of suggestions of electric motors in which was applied the principle of intermittent attraction by an electromagnet. Henry in 1831 and Dal Negro in 1832 produced see-saw mechanisms so operated. Ritchie in 1833 and Jacobi in 1834 devised rotatory motors. Ritchie pivoted a rapidly commutated electromagnet between the poles of a permanent magnet—a true type of the modern motor—while Jacobi caused two multipolar electromagnets, one fixed, one movable, to put a shaft into rotation and propel a boat. A perplexing diminution of the current of the battery whenever the motor was running caused Jacobi to investigate mathematically the theory of its action. In a masterly memoir he laid down a few years later the theory of electric motive power. But in the intervening period, in 1831, Faraday had made the cardinal discovery of the mechanical generation of electric currents by magneto-electric induction, the fundamental principle of the dynamo. Down to that date the only known way—save for the feeble currents of thermopiles—to generate electric currents had been the pile of Volta, or one of the forms of battery which had been evolved from it. Now, by Faraday's discovery, the world had become possessed of a new source. And yet again, strange as it may seem, years elapsed before the world—that is, the world of engineers—discovered that an important discovery had been made. Not until some thirty years later were any magneto-electric machines made of a sufficient size to be of practical service even in telegraphy, and none were built of a sufficient power to furnish a single electric light until about the year 1857. In the meantime in America other electric motors, to be driven by batteries, had been devised by Davenport and by Page; the latter's machine had an iron plunger to be sucked by electromagnetic attraction into a hollow coil of copper wire, thereby driving a shaft and flywheel through the intermediate action of a connecting-rod and crank. Page's was, in fact, an electric engine, with 2-foot stroke, single-acting, of between 3 and 4 horse-power. The battery occupied about 3 cubic feet and consumed, according to Page, 3 lb. of zinc per horse-power per day. This must have been an under-estimate: for if Daniell's cells were used the minimum consumption for a motor of 100 per cent. efficiency is known to be about 2 lb. of zinc per horse-power per hour.

Electric Motive Power Impossible in 1857.

Upon the state of development of electric motors fifty years ago information may be gleaned from an exceedingly interesting debate at the Institution of Civil Engineers upon a paper read April 21, 1857, "On Electromagnetism as a Motive Power," by Mr. Robert Hunt, F.R.S. In this paper the author states that, though long-enduring thought has been brought to bear upon the subject, and large sums of money have been expended on the construction of machines, "yet there does not appear to be any nearer approach to a satisfactory result than there was thirty years ago." After explaining the elementary principles of electromagnetism, he describes the early motors of Dal Negro, Jacobi, Davenport, Davidson, Page, and others. Reviewing these and their non-success as commercial machines, he says: "Notwithstanding these numerous trials . . . it does not appear that any satisfactory explanation has ever been given of the causes which have led to the abandonment of the idea of employing electricity as a motive power. It is mainly with the view of directing attention to these causes that the present communication has been written." He admits that electromagnets may be constructed to give any desired lifting power; but he finds that the attractive force on the iron keeper of a magnet of his own, which held 220 lb. when in contact, fell to 36 lb. when the distance apart was only one-fiftieth of an inch. To this rapid falling off of force, and to the hardening action on the iron of the repeated vibrations due to the mechanical concussion of the keeper, he attributed the small power of the apparatus. Also he remarked upon the diminution of the current which is observed to flow from the battery when the motor was running (which Jacobi had, in his memoir on the theory, traced to a counter electromotive force generated in the motor itself), and which reduced the effort exerted by the electromagnets; this diminution he regarded as impairing the efficiency of the machine. "All electromagnetic arrangements," he says, "suffer from the cause named, a reduction of the mechanical value of the prime mover, in a manner which has no resemblance to any of the effects due to heat regarded as a motive power." Proceeding to discuss the batteries, he remarked that as animal power depends on food, and steam power on coal, so electric power depends on the amount of zinc consumed; in support of which proposition he cited the experiments of Joule. He gives as his own results that for every grain of zinc consumed in the battery his motor performed a duty equivalent to lifting 86 lb. 1 foot high. Joule and Scoresby, using Daniell's cells, had found the duty to be equivalent to raising 80 lb. 1 foot high, being about half the theoretical maximum duty for 1 grain of zinc. In the Cornish engine, doing its best duty, 1 grain of coal was equivalent to a duty of raising 143 lb. 1 foot high. He put the price of zinc at 35*l.* per ton as compared with coal at less than 1*l.* per ton, which makes the cost of power produced by an electric motor—if computed by the consumption of zinc in a battery—about sixty times as great as that of an equal power produced by a steam-engine consuming coal. He concludes that "it would be far more economical to burn zinc under a boiler and to use it for generating steam power than to consume zinc in a battery for generating electromagnetical power."

In the discussion which followed, several men of distinction took part. Prof. William Thomson, of Glasgow (Lord Kelvin), wrote, referring to the results of Joule and Scoresby: "These facts were of the highest importance in estimating the applicability of electromagnetism, as a motive power, in practice; and, indeed, the researches alluded to rendered the theory of the duty of electromagnetic engines as complete as that of the duty of water-wheels was generally admitted to be. Among other conclusions which might be drawn from these experiments was this: that, until some mode of producing electricity as many times cheaper than that of an ordinary galvanic battery as coal was cheaper than zinc, electromagnetic engines could not supersede the steam-engine." Mr. W. R. Grove (Lord Justice Sir William Grove) remarked that a practical application of the science appeared to be still distant. The great desideratum, in his opinion, was not so much improvement in the machine as in the prime mover, the battery, which was the source of power. At present the only available use for this power must be confined to special purposes where the danger of steam and the creation of vapour were sought to be avoided, or where economy of space was a great consideration. Prof. Tyndall agreed with the last speaker, but suggested that there might be some way of mitigating the apparent diminution of power due to the induction of opposing electromotive forces in the machine itself. Mr. C. Cowper spoke of some experiments, made by himself and Mr. E. A. Cowper, showing the advantage gained by properly laminating the iron cores used in the motor. He put the cost of electric power at 4*l.* per horse-power per hour. He deprecated building electric motors with reciprocating movements and cranks; described the use of silver commutators; and mentioned the need of adjusting the lead given to the contacts. There was, he said, no reason to suppose that electric motors could be made as light as steam-engines. Even in the case of small motors of one-tenth or one-hundredth of a horse-power, for light work, where the cost of power was of small consequence, a boy or a man turning a winch would probably furnish power at a cheaper rate. Mr. Alfred Smee agreed that the cost would be enormous for heavy work. Although motive power could not at present be produced at the same expense on a large scale by the battery as by coal, still they were enabled readily to apply the power at any distance from its source; the telegraph might be regarded as an application of motive power transmitted by electricity. Mr. G. P. Bidder considered that there had been a lamentable waste of ingenuity in attempting to bring electromagnetism into use on a large scale. Mr. Joule wrote to say that it was to be regretted that in France the delusion as to the possibility of electromagnetic engines superseding steam still prevailed. He pointed out, as a result of his calorimeter experiments, that if it were possible so to make the electric engine work as to reduce the amount to a small fraction of the strength which it had when the engine was standing still, nearly the whole of the heat (energy) due to the chemical action of the battery might be evolved as work. The less the heat evolved, as heat, in the battery, the more perfect the economy of the engine. It was the lower intensity of chemical action of zinc as compared with carbon, and the relative cost of zinc and coal, which decided so completely in favour of the steam-engine. Mr. Hunt, replying to the speakers in the discussion, said that his endeavour had been to show that the impossibility of employing electromagnetism as a motive power lay with the present voltaic battery. Before a steam-engine could be considered, the boiler and furnace must be considered. So likewise must the battery if electric power were to become economical. Then the President, Mr. Robert Stephenson, wound up the discussion by remarking that there could be no doubt that the application of voltaic electricity, in whatever shape it might be developed, was entirely out of the question, commercially speaking. The mechanical application seemed to involve almost insuperable difficulties. The force exhibited by electromagnetism, though very great, extended through so small a space as to be practically useless. A powerful magnet might be compared to a steam-engine with an enormous piston, but with exceedingly short stroke; an arrangement well known to be very undesirable.

In short, the most eminent engineers in 1857 one and all condemned the idea of electric motive power as unpractical and commercially impossible. Even Faraday, in his lecture on "Mental Education" in 1854, had set down the magneto-electric engine along with mesmerism, homœopathy, odylism, the caloric engine, the electric light, the sympathetic compass, and perpetual motion as coming in different degrees amongst "subjects uniting more or less of the most sure and valuable investigations of science with the most imaginary and unprofitable speculation, that are continually passing through their various phases of intellectual, experimental, or commercial development, some to be established, some to disappear, and some to recur again and again, like ill weeds that cannot be extirpated, yet can be cultivated to no result as wholesome food for the mind."

Fifty Years Later.

Fifty years have fled, and Hunt, Grove, Smee, Tyndall, Cowper, Joule, Bidder, and Stephenson have long passed away. Lord Kelvin remains the sole and honoured survivor of that remarkable symposium. But the electric motor is a gigantic practical success, and the electric motor industry has become a very large one, employing thousands of hands. Hundreds of factories have discarded their steam-engines to adopt electric-motor driving. All travelling cranes, nearly all tramcars, are driven by electric motors. In the Navy and in much of the merchant service the donkey-engines have been replaced by electric motors. Electric motors of all sizes and outputs, from one-twentieth of a horse-power to 8000 horse-power, are in commercial use. One may well ask: What has wrought this astonishing revolution in the face of the unanimous verdict of the engineers of 1857?

The answer may be given in terms of the action and reaction of pure and applied science. Pure science furnished a discovery; industrial applications forced its development; that development demanded further abstract investigation, which in turn brought about new applications. It was beyond all question the development of the dynamo for the purposes of electrotyping and electric light which brought about the commercial advent of the electric motor. For about that very time Holmes and Siemens and Wilde and Wheatstone were at work developing Faraday's magneto-electric apparatus into an apparatus of more practical shape; and the electric lighthouse lamp was becoming a reality which Faraday lived to see before his death in 1867. That eventful year witnessed the introduction of the more powerful type of generator which excited its own magnets. And even before that date a young Italian had made a pronouncement which, though it was lost sight of for a time, was none the less of importance. Antonio Pacinotti in 1864 described a machine of his own devising, having a specially wound revolving ring-magnet placed between the poles of a stationary magnet, which, while it would serve as an admirable generator of electric currents if mechanically driven, would also serve as an excellent electric motor if supplied with electric currents from a battery. He thereupon laid down the principle of reversibility of action, a principle more or less dimly foreseen by others, but never before so clearly enunciated as by him. And so it turned out in the years from 1860 to 1880, when the commercial dynamo was being perfected by Gramme, Wilde, Siemens, Crompton, and others, that the machines designed specially to be good and economical generators of currents proved themselves to be far better and more efficient motors than any of the earlier machines which had been devised specially to work as electromagnetic engines. Moreover, with the perfection of the dynamo came that cheap source of electric currents which was destined to supersede the battery. That a dynamo driven by a steam engine furnishing currents on a large scale should be a more economical source of current than a battery in which zinc was consumed, does not appear to have ever occurred to the engineers who, in 1857, discussed the feasibility of electric motive power. Indeed, had any of them thought of it, they would have condemned the suggestion as chimerical. There was a notion abroad—and it persisted into the 'eighties—that no electric motor could possibly have an efficiency higher than 50 per cent. This notion, based on an erroneous understanding of the theoretical investigations of Jacobi, certainly delayed the progress of events. Yet the clearest heads of the time understood the matter more truly. The true law of efficiency was succinctly stated by Lord Kelvin in 1851, and was recognised by Joule in a paper written about the same date. In 1877 Mascart pointed out how the efficiency of a given magneto-electric machine rises with its speed up to a limiting value. In 1879 Lord Kelvin and Sir William Siemens gave evidence before a Parliamentary Committee as to the possible high efficiency of an electric transmission of power; and in August of the same year, at the British Association meeting at Sheffield, the essential theory of the efficiency of electric motors was well and admirably put in a lecture by Prof. Ayrton. In 1882 the present author designed, in illustration of the theory, a graphic construction, which has been ever since in general use to make the principle plain. The counter-electromotive force generated by the motor when running, which Hunt and Tyndall deplored as a defect, is the very thing which enables the motor to appropriate and convert the energy of the battery. Its amount relatively to the battery's own electromotive force is the measure of the degree to which the energy which would otherwise be wasted as heat is utilised as power. Pure science stepped in, then, to confirm the possibility of a high efficiency in the electric motor *per se*. But pure science was also brought into service in another way. An old and erroneous notion, which even now is not quite dead, was abroad to the effect that the best way of arranging a battery was so to group its component cells that its internal resistance should be equal to the resistance of the rest of the circuit. If this were true, then no battery could ever have an efficiency of more than 50 per cent. It was supposed in many quarters that this misleading rule was applicable also to the dynamo. The dynamo makers discovered for themselves the fallacy of this idea, and strove to reduce the internal résistance of the armatures of their machines to a minimum. Then the genius of the lamented John Hopkinson led him to apply to the design of the magnetic structure of the dynamo abstract principles upon which a rational proportioning of the iron and copper could result. A similar investigation was independently made by Gisbert Kapp, and between these accomplished engineers the foundations of dynamo design were set upon a scientific basis. To the perfection of the design the magnetic studies of our ex-President, Prof. Ewing, contributed a notable part, since they furnished a basis for calculating out the inevitable losses of energy in armature cores by hysteresis and parasitic currents in the iron when subjected to recurring cycles of magnetisation. Able constructive engineers, Brown, Mordey, Crompton, and Kapp, perfected the structural development, and the dynamo within four or five years became, within its class, a far more highly efficient machine than any steam engine. And as by the principle of reversibility every dynamo is also capable of acting as a motor, the perfection of the dynamo implied the perfection, both scientific and commercial, of the motor also. The solution in the 'eighties of the problem how to make a dynamo to deliver current at a constant voltage when driven at a constant speed, found its counterpart in the solution by Ayrton and Perry of the corresponding problem how to make a motor which would run at constant speed when supplied with current at a constant voltage. Both solutions depend upon the adoption of a suitable compound winding of the field magnets.

A little later alternating currents claimed the attention of engineers; and the alternating current generator, or "alternator," was developed to a high degree of perfection. To perfect a motor for alternating currents was not so simple a matter. But again pure science stepped in, in the suggestion by Galileo Ferraris of the extremely beautiful theorem of the rotatory magnetic field, due to the combination of two alternating magnetic fields equal in amplitude, identical in frequency and in quadrature in space, but differing from each other by a quarter-period in phase. To develop on this principle a commercial motor required the ingenuity of Tesla and the engineering skill of Dobrowolsky and of Brown: and so the three-phase induction motor, that triumph of applied science, came to perfection. Ever since 1891, when at the Frankfort Exhibition there was shown the *tour de force* of transmitting 100 horse-power to a distance of 100 miles with an inclusive efficiency of 73 per cent., the commercial possibility of the electric transmission of power on a large scale was assured. The modern developments of this branch of engineering and the erection of great power-stations for the economic distribution of electric power generated by large steam plant or by water-turbines are known to all engineers. The history of the electric motor is probably without parallel in the lessons it affords of the commercial and industrial importance of science.

But the query naturally rises: If a steam-engine is still needed to drive the generator that furnishes the electric current to drive the motors, where does the economy come in? Why not use small steam-engines, and get rid of all intervening electric appliances? The answer, as every engineer knows, lies in the much higher efficiency of large steam-engines than of small ones. A single steam-engine of 1000 horse-power will use many times less steam and coal than a thousand little steam-engines of 1 horse-power each, particularly if each little steam-engine required its own little boiler. The little electric motor may be designed, on the other hand, to have almost as high an efficiency as the large motor. And while the loss of energy due to condensation in long steam-pipes is most serious, the loss of energy due to transmission of electric current in mains of equal length is practically negligible. This is the abundant justification of the electric distribution of power from single generating centres to numerous electric motors placed in the positions where they are wanted to work.

Education and Training of Engineers.

Interplay of action and reaction make for progress not only in the evolution of the scientific industries, but also in the development of the individual engineer. In him, if his training is on right lines, pure theory becomes an aid to sound practice; and practical applications are continually calling him to resort to those abstractions of thought, the underlying principles, which when known and formulated are called theories. Recent years have brought about a so much better understanding of education, in its bearing upon the professions and constructive industries, that we now seldom hear the practical man denouncing theory, or the theorist pooh-poohing practice. It is recognised that each is useful, and that the best uses of both are in conjunction, not in isolation. As a result of this better understanding distinct progress is being made in the training of engineers. Of this the growth of the engineering departments of the universities, and of the technical colleges and schools, affords striking evidence. The technical schools, moreover, are recognising that their students must have a sound preliminary education, and are advancing in the requirements they expect of candidates for admission. They are also finding out how their work may best supplement the practical training in the shops, and are improving their curricula accordingly. In the engineering industry, too, Great Britain is slowly following the lead taken in America, Germany, and Switzerland, in the recognition afforded to the value of a systematic college training for the young engineer, though there is still much apathy and even distrust shown in certain quarters. Yet there is no doubt that the stress of competition, particularly of competition against the industry and the enterprise of the trained men of other nations, is gradually forcing to the front the sentiment in favour of a rational and scientific training for the manufacturer and for the engineer. As William Watson, in his "Ode on the Coronation," wrote in a yet wider sense of England:—

> For now the day is unto them that know,
> And not henceforth she stumbles on the prize:
> And yonder march the nations full of eyes.
> Already is doom a-spinning. . . .

Truly the day is "unto them that know." Knowledge, perfected by study and training, must be infused into the experience gained by practice: else we compete at very unequal odds with the systematically trained workers of other nations. Nor must we make the mistake here in the organisation of our technical institutions of divorcing the theory from its useful applications. In no department is this more vital than in the teaching of mathematics to engineering students. For while no sane person would deny that the study of mathematics, for the sole sake of mathematics, even though it leads to nothing but abstract mathematics, is a high and ennobling pursuit, yet that is not the object of mathematical studies in an engineering school. The young engineer must learn mathematics not as an end in itself, but as a tool that is to be useful to him. And if it is afterwards to be of use to him, he must learn it by using it. Hence the teacher of mathematics in an engineering school ought himself to be an engineer. However clever he be as a mathematical person, his teaching is unreal if he is not incessantly showing his learners how to apply it to the problems that arise in practice; and this he is incapable of doing if these problems do not lie within his own range of experience and knowledge. Were he a heaven-born senior wrangler, he is the wrong man to teach mathematics if he either despises or is ignorant of the ways in which mathematics enter into engineering. The fact is that for the great majority of engineering students, the mental training they most need is that which will enable them to think in physics, in mechanics, in geometric space, not in abstract symbols. The abstract symbols, and the processes of dealing with their relations and combinations, are truly necessary to them: but they are wanted not for themselves, but to form convenient modes of expressing the physical facts and laws, and the interdependence of those physical facts and laws. When the student loses grip of the physical meaning of his equations, and regards them only as abstractions or groupings of symbols, woe betide him. His mathematics amount to a mere symbol-juggling. That is how paper engineers are made. The high and dry mathematical master who thinks it beneath him to show a student how to plot the equations $y=A\sin x$, or $r=b\sin\theta$, or who never culls an example or sets a problem from thermodynamics or electricity, must be left severely on one side as a fossil. Better a living Whitworth scholar than a dry-as-dust Cambridge wrangler. He at least knows that elasticity is something more real than the group of symbols $E=p\div\frac{\Delta x}{x}$, which any mathematician may "know," even though he be blissfully ignorant whether the force required to elongate a square-inch bar of steel by one one-millionth of its length is ten ounces or ten tons.

One evidence of the wholesome change of opinion that is springing up concerning the training of engineers is the abandonment of the system of taking premium pupils into works with no other test or qualification than that of the money-bag. Already many leading firms of engineers have been finding that the practice of taking sons of wealthy parents for a premium does not answer well, and is neither to their own advantage nor in many cases to that of the "pupil," whom it is nobody's particular business in the shops to train. Premium pupilage is absolutely unknown in the engineering firms of the United States or on the Continent of Europe. The firms who have abandoned it are finding themselves better served by taking the ablest young men from the technical schools and paying them small wages from the first, while they gain experience and prove themselves capable of good service. Messrs. Yarrow and Co. have led the way with a plan of their own, having three grades of apprenticeship, admission to which depends upon the educational abilities of the youths themselves. Messrs. Siemens have adopted a plan of requiring a high preliminary training. The Daimler Motor Company has likewise renounced all premiums, preferring to select young men of the highest intelligence and merit. Messrs. Clayton and Shuttleworth have quite recently reconstructed their system of pupil-apprenticeship on similar lines. The British Westinghouse Company and the British Thomson-Houston Company have each followed an excellent scheme for the admission of capable young men. Even the conservatism of the railway engineers shows signs of giving way; for already the Great Eastern Railway has modernised its regulations for the admission of apprentices. What the engineering staffs of the railway companies have lost by taking in pupils because of their fathers' purses rather than for the sake of their own brains it is impossible to gauge. But the community loses too, and has a right to expect reform.

To this question, affecting the whole future outlook of engineering generally, a most important contribution was made in 1906 by the publication by the Institution of Civil Engineers of the report of a committee (appointed in November, 1903) to consider and report to the Council upon the subject of the best methods of education and training for all classes of engineers. This Committee, a most influential and representative body consisting of leading men appointed by the several professional societies, the Institutions of Civil, Mechanical, and Electrical Engineers, the Institution of Naval Architects, the Iron and Steel Institute, the Institution of Gas Engineers, the Institution of Mining Engineers, and two northern societies, was ably and sympathetically presided over by Sir William H. White. Its inquiries lasted over two years and included the following sections: (1) Preparatory Training in Secondary Schools; (2) Training in Offices, Workshops, Factories, or on Works; (3) Training in Universities and Higher Technical Institutions; (4) Post-graduate Work. The findings of this Committee must be received as the most authoritative judgment of the most competent judges. So far as they relate to preparatory education they suggest a modernised secondary school curriculum in which there is no one specialised scientific study, but with emphasis on what may be called sensible mathematics. They also formulated one recommendation so vital that it must be quoted in full:—

"A leaving examination for secondary schools, similar in character to those already existing in Scotland and Wales, is desirable throughout the United Kingdom. It is desirable to have a standard such that it could be accepted by the Institution [of Civil Engineers] as equivalent to the Studentship Examination, and by the Universities and Colleges as equivalent to a Matriculation Examination."

One may well wonder why such a reasonable recommendation has not long ago been carried out by the Board of Education. Perhaps it has been too busy over the religious squabble to attend to the pressing needs of the nation.

The second set of recommendations relates to engineering training. It begins with the announcement that "long experience has led to general agreement among engineers as to the general lines on which practical training should proceed"; but goes into no recommendations on this head beyond favouring four years in workshops, on works, in mines, or in offices, expressing the pious desire that part of this practical training should be obtained in drawing-offices, and suggesting that during workshop-training the boys should keep regular hours, be subject to discipline, and be paid wages. It then lays down a dozen recommendations as to the "academic" training suitable for the average boy. He should leave school about seventeen; he should have a preliminary year, or introductory workshop course of a year, either between leaving school and entering college, or after the first year of college training. If the workshop course follows straight on leaving school there must be maintenance of studies either by private tuition or in evening classes, so that systematic study be not suspended. For the average student, if well prepared before entering College, the course should last three academic years (three sessions); in some cases this might be extended to four or shortened to two. A sound and extensive knowledge of mathematics is necessary in all branches of engineering, and those departments of mathematics which have no bearing upon engineering should not claim unnecessary time or attention. The Committee strongly recommends efficient instruction in engineering drawing. The college course should include instruction (necessarily given in the laboratory) in testing materials and structures, and in the principles underlying metallurgical processes. In the granting of degrees, diplomas, and certificates, importance should be attached to laboratory and experimental work performed by individual students, and such awards should not depend on the results of terminal or final examinations alone.

All this is most excellent. It will be seen that it is entirely incompatible with the premium-pupil system, which may therefore be regarded as having been weighed and found wanting. For two things clearly stand out; that the young engineer must be college-trained, and that when he goes to works he should be regularly paid. It would have been well if the Committee could have been more explicit as to the proper course of workshop training: for instance as to the systematic drafting of the young engineer through the shops—forge, foundry, pattern-shop, fitting-shop, &c., and as to the proper recognition of the duty of the shop-foreman to allocate work to the novice in suitable routine. These are doubtless among the matters in which "long experience has led engineers to general agreement." But this being so, it would have been well to state them authoritatively. A notable feature of this report is its healthy appreciation of the advantages of training, and an equally healthy distrust of the practice of cramming for examinations. So soon as any subject is crammed, it ceases to afford a real training. "Nature provides a very convenient safety-valve for knowledge too rapidly acquired." It is even whispered that a new species of crammer has arisen to "prepare" candidates in engineering for the graduate examinations of the Institution of Civil Engineers. The distinguished framers of this epoch-making report on the education and training of engineers at least give no countenance to any such parasitical development. For the scheme of education and training at which the Committee has aimed is genuinely scientific, a happy federation of the theoretical with the practical. It seeks to place the training on a broad basis, and to secure to every future engineer worthy of the name the advantage of learning his professional work in both its aspects. It seeks, in short, to take advantage of that reflex action between science and its applications in which lies the greatest stimulus to progress. Its adoption will utilise for the young engineer, and therefore for the engineering industry as a whole, the facilities for training now so widely afforded throughout the country. If the institutions, schools, and colleges where engineering training is offered are but rightly developed and co-ordinated, the engineers of Great Britain need have no fear as to holding their own against the trained engineers of other countries. It is for the employers to make use of these institutions, and to show that sympathetic interest in their efficiency which is essential to their full success.

SECTION H.

ANTHROPOLOGY.

OPENING ADDRESS BY D. G. HOGARTH, M.A., PRESIDENT OF THE SECTION.

Religious Survivals.

THE science of Anthropology, from its very nature, seldom touches the beliefs or customs of the higher actual civilisations; but exceptions occur when it enters the field of comparative religion. In coming to the aid of this fascinating study it can hardly help offending, sooner or later, certain prejudices which are deeply rooted and widely distributed, and that not only when it really contravenes the beliefs of pious minds, but, often enough, when its exponents neither wish to impair these beliefs, nor, as a matter of fact, are taking any steps to do so; for the opposition which meets science when it concerns itself with religion is very frequently arrayed before the opponent has taken the time or the trouble to ascertain whether anything vital or essential is concerned in the investigation. At any rate it will be allowed that the majority of the treatises on this study written in the English tongue do not, by any lack of reverent treatment or by any obvious oblivion of the responsibility resting on those who inquire into the religious basis of our social order, display any desire to offend. But just because some offence must almost inevitably be given, even by the most reverent anthropologist, in pursuing investigations which involve examination of actual pious beliefs, it is especially incumbent on students of this particular subject to proceed only along the most strictly judicial lines, careful not to force a conclusion from evidence which is in any respect dubious or even incomplete; and, moreover, to be quite clear in their own minds and to make it clear to others how far their investigation really touches actual religion in vital and essential points of belief as distinguished from mere points of observance or ritual, *i.e.*, religious accidents, as they might be called. Obvious as this caution may seem, neglect of it is very general, and has led to much needless suspicion of Anthropology as a science with covert and far-reaching purpose, subversive of all religion.

It is in the interests of definition and clearness in a controversial topic among the religious inquiries of anthropologists that I have chosen my theme to-day. I have small claim to expound the science, as usually understood, to which this Section is devoted, whether on its physical or on its social side, so far as the latter is principally concerned with actual custom and folklore. But as one who has spent more than twenty years in studying the ancient life of that region of the world in which three of the greatest actual systems of religion were developed, and a good part of his time among the modern peasantry of the region itself, I have had my attention particularly directed to the evolution of religious beliefs and observances during long periods of time, which are unusually well illuminated for us from first to last by the light of both monuments and literature; and that attention has often been arrested by striking instances of *cultus* continuity under successive religious systems or dispensations. I enjoyed the advantage of beginning travel in the Nearer East in the company of the acute observer who is now Sir William Martin Ramsay, and to his comments on what we saw together in the Phrygian highlands as long ago as 1887 I owe much of my earliest interest in the question of religious survival and my direction towards the lines on which I have since tried to study it. Some day let us hope that, prompted by such a lectureship as the Gifford Foundation, or encouraged by some discerning publisher, Sir William Ramsay may collect from his many books the observations scattered here and there upon the religious elements which survived from Anatolian heathendom into both Christian and Moslem observance, and adding to them others from the storehouse of his memory and his notebooks, produce a volume parallel to that "Religion of the Semites" which is the abiding memorial of his dead friend and ally.

I have called "Religious Survivals" a controversial topic. That is to put it mildly. Indeed, few anthropological topics generate so much heat. In addition to a common distaste with which one may sympathise, even if one does not share it, manifested by many reverent minds for all objective discussion of things religious, this topic challenges a certain very widespread prejudice, as irrational as it is strong—namely, the prejudice against the inclusion of orthodox religious beliefs and observances under the general maxim, "There is nothing new under the sun." The more sacred a man holds anything the less will he believe that evolution has had anything to do with it—evolution with its inevitable implication of embryonic and imperfect stages. The Athenian loved to think that the great patron goddess of his city sprang fully grown and fully armed from the head of the King of heaven. The devotees of all creeds have wished to believe that when the first founders of systems proclaimed their missions the old things passed away like a burning scroll and a wholly new earth and heaven began. Nothing is more repugnant to the ordinary orthodox Moslem than the suggestion that the Prophet borrowed theology and doctrine from earlier Semitic systems, notably the Hebraic, and that much of the ceremonial and observance now followed by the faithful in their most religious moments, those of the Meccan pilgrimage, survive from the times of ignorance. Yet what contentions are less controvertible in fact than these? The devotee can believe that every detail of a new dispensation was known from all time in heaven, but will refuse to allow that anything can have been known on earth. With that direct revelation which he thinks to have been vouchsafed at a given moment from on high, the slate of time must have been wiped clean of all previous religious thought and practice. I do not, of course, speak for one moment of the enlightened and scholarly doctors of our own creed or any other. These have always seen and often stated that the religious systems by which they hold have assimilated much from systems of earlier date; nor in admitting that have they found their faith take any harm.

How natural and compelling, however, is the prejudice in question may be estimated by the fact that it is extended to dispensations in other fields than the religious. For example, that message to civilisation which it was given to the pagan Hellene to deliver does not admit in the view of certain devout Hellenists of the view that the Greek artistic sense had any pedigree in pre-classical times. They resent as an insolent innuendo the contention that what is essential in the Greek spirit can be detected in the work of peoples living in the Hellenic area long before the rise of classic Hellenic art, and that from these peoples and from others who possessed older civilisations the fabric of Hellenism was built up in strata, which can still be observed, and referred to their pre-Hellenic authors. So close akin is *odium archæologicum* to *odium theologicum*! Yet, perhaps, in this case they are really one and the same, for perfervid Hellenism is the last half-conscious protest of the Western peoples of Europe against the dominance of an Asiatic religion.

Irrational is this prejudice in the first degree of course, because not only have we the clearest historical evidence that in our own religious practice, as in that of other races, details of earlier ritual and observance have survived, often by conscious and intentional adoption, but also, as Robertson Smith well said, "experience shows that primitive religious beliefs are practically indestructible, except by the destruction of the race in which they are ingrained." All apostles of new creeds have had to preach to and gain the adherence of societies which they could not hope to lead to a perfect way all at once or even in centuries of time, and all have had to take account of the pre-existing habits of religious thought and actual expressions of religious feeling, and by accepting some compromise to modify these to their purpose. And if this be obviously true of those societies which such an apostle as Mohammed could influence directly and retain under some sort of personal control, what must we say of the societies to which the truth only came at second hand or by many more degrees removed from the original prophetic utterance? What of the remote or scattered folk to whom it came not at all till after a long interval, and then faint and confused as a reverberating echo? For these at least there was no possibility of such utter change as revelation working through the human agency of a magnetic personality may have effected elsewhere; and of their belief and their practice much, perhaps the most, has remained primæval and local, and as the physical conditions of their life have prompted it from all time to be, and prompt still.

All this stratification in religious belief and practice it is the function of Anthropology to investigate; and thereby it may render no small service to religion itself by distinguishing accidental elements in ritual and observance which have persisted from systems worn out and abandoned. But while proclaiming that this investigation is not only legitimate but necessary, I wish to-day to utter a note of warning against a certain confusion of thought which is often manifested by the investigators in this particular field, and is apt to occasion unfortunate ethical consequences or, at the best, unnecessary scandal. It finds expression in the grouping of all the elements in belief, observance, and ritual, which have persisted from earlier systems to later, under one head as religious survivals, without due account being taken of very vital differences, both in their essential nature and in the history and reason for their persistence. The word "survival" itself is *per accidens* not a very fortunate one. Though in the broad sense perfectly appropriate to all things that persist, it has acquired in our modern speech, largely from its use in medical science, a certain particular connotation of opprobrious import. It suggests something which has lost its useful purpose, and is effete or even dead, persisting among living organisms usually to their detriment. Such is the sense in which many anthropologists seem to use the word in speaking of religious persistences without discriminating between divers kinds of these; and such, still more often, is the connotation which their readers attach to the word in this connection. Yet all religious persistences are not survivals in this pathological sense—nay, the class to which this connotation is suitable includes but a small proportion of the whole. It is to distinguishing these classes of survivals that I propose to address myself in the remainder of the time which is allotted to me to-day.

In the first place there is a most numerous and important body of religious persistences which ought not to be called survivals at all, if that word be used, as it usually is, with a causative implication; that is to say, there are elements of belief and practice the existence of which in actual cult is not necessarily due at all to the fact that they, or something very closely akin, existed in a previous cult. If religion is the expression of the instinctive desire of man to find an intelligible relation between his own nature and a nature which transcends its limitations, he appears unable to establish that relation by other than a very small and definite number of conceptions; and among certain races, and indeed in certain geographical areas, those conceptions seem not to vary over immense spaces of time and under successive dispensations. The just way to regard them, therefore, is as falling within categories of thought inevitably imposed on the human mind by its humanity and necessary conditions of any religious sense whatever. Man does not form these conceptions because his predecessors formed them, nor indeed because his contemporaries hold them; but because, as an individual limited by race and environment, he cannot otherwise satisfy his religious instinct. How important this class is, and how much it includes which has often been discussed by anthropologists under the head of religious survival, may be judged if we recall that there falls under it such an article of belief as the Incarnation of God with all its consequences of expression—the immaculate conception, atoning death, and bodily resurrection. Neither this belief nor any of its expressions, I need hardly say, make their appearance for the first time in Christianity. They are to be recognised as forms—necessary categories of creed if you will—under which races of the Nearer East and of other regions of the world also have conceived the relation between the human and the divine as far back as we know anything of their history. But since anthropological knowledge concerning this delicate and difficult instance has been set forth lately in full detail by a distinguished student of religious persistences, Mr. J. G. Frazer, in his "Adonis, Attis, and Osiris," I feel no obligation to deal with it further than to remind you that, apart from all question whether Christian tradition states historical facts in this matter, nothing which Anthropology has collected in the way of comparative facts from other creeds serves to place either this belief or its form of expression among religious survivals in the narrower sense—that is to say, among religious elements which appear in Christianity merely because they existed in earlier religions. Much accidental circumstance has beyond doubt attached itself to this Christian tenet from the previous cult observances and ritual of the many races which it has convinced; and to certain of these I shall call attention presently when I come to deal with another class, more properly to be called religious survivals; but as for the essentials of the belief, they have as much right to be regarded as independent conceptions of Christianity, despite their earlier appearance in other religions, as history proclaims them to have been endued by Christianity with a wholly new ethical significance.

But in order to fortify my generalities with a particular example, I may be allowed to deal in brief detail with another, though related, religious conception of the same class, which has not been so exhaustively treated by anthropologists. As a student of Mediterranean races and a frequent observer of their actual representatives, I have often been struck by the persistent dominance of femininity in their conception of the Divine, and equally by the distinction which that fact makes between their instinctive creeds and those of other races domiciled contiguous to them, but round an outer radius. In fact, it would not be difficult to draw a broad frontier line at a certain distance inland round the Mediterranean area from the Atlantic to the African deserts, within which a Goddess has always reigned supreme in the hearts of the unsophisticated folk, with a God occupying only a subordinate, and often demonstrably a less primæval, throne; while without it the God has been dominant and feminine divinity secondary. Within the frontier lie the peninsular and other littoral districts with a broad *hinterland* of mountainous or hilly regions. With the great continental plains begins the outer and contrasted circle. The predominance of a great Nature Goddess among all the races of the East Mediterranean basin in the earliest historic time is well known; and to what had been ascertained of her among the Semites, under her many names, Tanith, Al-Lat, Baalit, Ishtar, Atta, Ashtaroth—these last but variants of one appellation; among the Nilotic peoples also under many names, *e.g.*, Neith and Isis; among the Anatolian races as the Great Mother, Kybele, Ma, and the unknown "Hittite" title; among the historic inhabitants of Greece and the Ægean as Rhea, Artemis, Britomartis, and a score of other appellations; among the Italic tribes, as Diana or local variants, there has been added latterly the discovery that a Goddess of character and attributes, readily to be compared with those of the Nature deity in various parts of the surrounding area, was dominant in the religion of that important artistic race which occupied the Ægean in the prehistoric age, and had so much influence on the momentous civilisation of its later time—that race which has been rescued from long oblivion by Schliemann in Greece and Troy, and by Evans and others in the Isles. The more we learn of this great Nature- or Mother-Goddess, the more primæval and predominant is the position she is seen to hold. All round the Eastern Mediterranean she was before all created things: she became the mother of a son by spontaneous generation or some other process independent of the male—an idea, it may be remarked, which presents no impossiblity to the minds of very primitive races, some of whom even at this day do not connect fertilisation and conception as cause and effect. With her son she produced all life: she gave her son to the humanity so created, and humanity killed him that it might live; he revived and returned again to his mother, was again killed, and so the cycle of the seasons revolved. So far as concerns Him in all his *avatars* Mr. Frazer's book may be consulted. As for Her, a Woman still holds the same place in the religious belief of the old races of the same region, wherever they have escaped assimilation by conquering races and faiths from beyond the border. Hear any Greek or Italian peasant in a moment of excitement or danger. He calls on no Person of the Trinity, but on the Virgin. For him her power does not come from her Motherhood of her Son. Indeed, I have known Christian countrymen of a West Anatolian valley to whom that motherhood was evidently unknown, and when spoken of remained without interest or significance. She is a self-sufficient, independent embodiment of divinity, to whom the ruder folk of Mediterranean lands offer their prayers and pay their vows alone. She and no other is beseeched to grant increase and fertility; she and no other is credited with the highest direction of human affairs. But to say, as so often is said, that, for instance, in Greek lands the Panaghiá is simply a survival of Artemis or Aphrodite under another name, is to convey a false impression. She stands for the same principle of divinity as they; she has taken on, as I shall point out presently, even the feasts and the ritual of her predecessor; and she has often made peculiarly her own the spots especially sacred to the earlier Mother-Goddess. But, as I take it, she is not worshipped now in Ephesus or Cyprus merely because there was once a dominant cult of Artemis or Aphrodite in those places, but because to the peoples of a wide Mediterranean region it is still, as it always was, a religious necessity to embody their idea of divinity in the feminine; and I would state the relation of the Christian Virgin-Goddess to the pagan one rather in this way—that, coming from without, she gained acceptance at once for herself, and probably also, in a great measure, gained acceptance for the whole creed with which she was connected, because she offered a possible personification of the same principle which had always been dominant in the local religion.

Why that principle was so deeply rooted in the peoples of this particular region I cannot pretend precisely to say. To ascribe it, as has been suggested, to the original prevalence of *Mutterrecht* is probably to mistake effect for cause. The principle has its roots deeper down than even the matriarchal system. In a general way we may hold it the result of a peculiar mental concentration upon the idea of generation and reproduction of life, upon the increase of man, the brute creation, and the earth. In these processes the more obvious part played by the female in Nature inevitably tends among primitive peoples, who are comparatively peaceful and more of agriculturists and herdsmen than warriors or hunters, to make woman seem the sole condition of their being and the predominant arbiter of their destinies. More we can hardly say. We cannot determine whether there were peculiar geographical conditions in the dawn of time, which, either in some other home or in the Eastern Mediterranean region itself, predisposed the ancestors of the actual races of the latter to this cult of the reproductive force. One can but bear witness that at the present day this idea is an obsession of these inhabitants wherever they remain in a comparatively simple state of society. All their thoughts, their prayers, and their actions seem to be inspired by it, and of all their thoughts, their prayers, and their actions—so far as they have not been warped to the Father-God of the Southern Semites by the armed pressure of an alien folk from the warlike steppes of Northern Asia—Mary, the Panaghiá, is the focus.

In her essential identification with the religious sense of these peoples, therefore, the Virgin is no mere survival. But in an accidental or secondary sense her actual personality may, perhaps, be so regarded in the region in question if we are careful to exclude from the word all connotation of superfluity or decaying energy. Her cult may be brought under that body of beliefs, observances, and practices which have demonstrably passed from earlier religious system to later by processes of transference, usually unconscious, but often half-conscious, and undoubtedly in some cases wholly conscious. Where the process has been unconscious or half-conscious these beliefs, observances, and practices have survived in the new system because the religious sense of the masses felt instinctively that they were necessary to its expression. They cannot therefore be regarded as survivals with any implication of decay or death. They were necessities under the former system; they remained necessities under the later, and may be living forces and vital expressions of the human desire for relation with the divine under the new as much as under the old. Where the process has been conscious a popular demand for their survival as necessities has been appreciated by leaders of the system, and observances and forms of ritual have been consciously taken from the old system to express a principle still active under the new. Often we are in a position to know that the old beliefs, observances, and forms did not accord with the highest ideals of the most advanced professors of the new system, and that they came to be consciously adopted by compromise in the interests of the more rapid and permanent establishment of the latter among inferior intelligences. They were better than the worse, if not as good as the best. Of these Dr. Bigg is speaking in the preface to his book "The Church's Task under the Roman Empire" when he says, "The most significant changes in history were not imposed upon the Church by the bishops from above, but forced upon the bishops by the pressure of popular opinion from below." A well-known example is supplied by the early history of Islam, when the Prophet, having learned in exile at Medina, what many of his apostles have since had to learn, that the Semitic masses could not be weaned to a perfectly spiritual system, came to terms with the primæval worship of the Arabian Goddess in Mecca and displaced her personality by retaining many expressions of the popular cult of her; and, as so often has happened in similar cases of religious transference, those expressions remaining to this day the most strictly observed by Moslems, testify still to the vitality of the religious necessity which lay and lies behind them. And not only the early history of Islam, but the early history of Christianity offers instances of such conscious transference, some of which may be read of in Sir William Ramsay's works, *e.g.*, in "The Church in the Roman Empire," where he deals with that strange story of Glycerius the Cappadocian deacon, who broke out at a certain great gathering of Christians at Venasa, one of the holiest of the pagan high places of the land, and revived the former orgiastic form of cult by leading a band of enthusiastic maidens dancing and singing through the hills to the glory of Christ crucified. Condemned in haste by the stern Basil of Cæsarea, the recalcitrant deacon found an apologist and a protector in no less saintly a priest than Gregory of Nazianzos, who knew better than his Metropolitan how real and deep a local religious instinct lay beneath this scandalous manifestation, and how much better it were to bend to the service of the Church, than to break, the religious zealots who had expressed it. Another curious collection of such transferences may be found in a recent work of Mr. Rendel Harris, which he entitled "The Heavenly Twins." Here are set out an immense number of facts and suggestions tending to show how the early Church adapted to its ends the cult of the Dioscuri or of similar twin gods known by other names both in the West and East, a cult which expressed a certain conception of the relation between human and divine, salutary and indeed necessary to many pagan minds. The book needs to be read in a critical spirit, for the author has been led on by the fascination of myth-interpretation to find his twin nature-gods wherever he turns to look for them; and often his reading of the legends is less convincing than would be (if it is allowed to use a frivolous instance in such a connection) a similar explanation applied to the story of Box and Cox—those obvious twins of Dark and Light who occupied, turn and turn about, their chamber, the World, under the benign influence of the landlady of the tale, a manifest Earth-Mother of mythology.

Many of the undoubted transferences which took place under the Christian system cannot at this time of day be certainly distinguished into the conscious and the unconscious. We know that saints of the Church have entered often into the honour and the local habitations of pagan deities. Mr. Frazer has told us how St. Felicita has replaced Mephitis, the heathen personification of the poisonous gas of the pool of Frigento, and how Adonis in Sicily and Sardinia lives on as St. John. These instances might be multiplied to many hundreds. We know, too, that almost all our stated ecclesiastical festivals are continuations of heathen feasts, so far as their dates and the general nature of their commemorative significance are concerned. What had to be changed has been changed, but not more. Christmas has succeeded to the festival of the winter solstice which celebrated the new birth of the Sun; Easter to the spring festival at which in many parts of the Mediterranean world the Nature-Goddess, and especially the death and resurrection of her Son, were commemorated. The Assumption of the Virgin replaces the August feast of Artemis and Diana in Greece and Italy. The anniversary of St. George, so great a day in modern Greece, seems to be the old Parilia; St. John the Baptist has taken on the heathen rites of midsummer, and you may see the folk of Smyrna, Christian and Moslem alike, jumping through fire to his honour on any St. John's Eve. Very rarely, as in the case of the Feast of All Souls, the late Christian adoption of which in the tenth century happens to be known, can we ascribe these transferences to any definite action of a leader of the Church. Usually we know no more than that where and when there was once a pagan saint or a pagan feast there are now saints and feasts of Christianity. But no reasonable person feels that the latter are discredited or lose anything of their actual significance by the fact of their having a pre-Christian pedigree. St. John may have succeeded to Adonis, but he is not Adonis. Christmas may be the heir of the Saturnalia, but it is the Saturnalia no longer. To feel that the sanctity of either is impaired by these facts is as if one were to refuse reverence to the art-types of early Christianity, because most unquestionably these were not invented fresh and new for the new religion. Why should they have been? If there were ready to hand images in pagan art, fit to express the early Christian ideas, it would have needed a miracle for the nascent Church to have invented new ones. The human creative faculty in matters of art is strictly limited as to types. Presentations of Apollo or Orpheus were used naturally for the new Christ, and those of the Nature-Goddess of Asia with her Son for the new Mother and Child. How else should gracious maternity have been represented? Last year I showed in this Section certain terra-cotta images of the Ephesian Goddess with her child, dated to the fourth century before Christ, which might easily have been mistaken for Madonna figures of the Italian Renaissance; and last winter I saw in a newly excavated Coptic chapel of the sixth century at Memphis a fresco painting of the Virgin suckling her Son which was indistinguishable from late representations of Isis.

As a matter of fact there is little fear that anthropologists in demonstrating the fact of transference in such categories of religious expression as these with which I have just been dealing will impair their religious efficiency. For, after all, how much is there not in the everyday expression of the religious sense among ourselves which has suffered a transference in time and space so obvious that no reflective mind can be unconscious of it? Consider only the religious phraseology current among the simplest Christians all that mass of images and ideas proper to an alien race and to the latitude and climate of the Mediterranean in which, for example, the Presbyterian of Scotland expresses the most pious of his aspirations. He sighs for the shadows of great rocks in a weary land, for the plash of running waters, for the shade of the fig and the vine; and, the most restless of men to whom all inaction is hateful, he aspires to a heaven floored with the crystal of Oriental imagery, where he shall for ever sit still. These ideas one meets at every turn, not only in religious, but in the secular, thoughts of every Oriental or South European. Among us they appear in religion only, known for manifest exotics, but not the less full of religious significance, even to the lease congruous Christian.

Ere I leave this second class of Survivals let me revert again for a moment to the cult of the Virgin in the Nearer East. It is possible, even probable, that Mary, the mother of Jesus, also owes her divine, or at least semi-divine, position in the Christian system to such a conscious effort by leaders of the Church as those to which we have just alluded. It is a well-known fact that neither the primary nor the secondary authorities for the first two centuries of Christianity supply any warrant for the position which she was to hold later. They are, in fact, almost silent about her. Nor has Christian archæology discovered any better evidence of her glorification above other holy women during that time. It seems established that it was not till the third century that she began to assume semi-divinity. By the fourth her position was sufficiently exalted to cause the schism associated with the name of Nestorius, whatever the real views of that ecclesiastic may have been; but it was not till A.D. 431 that she was officially acknowledged by a General Council to be divine in virtue of her Theotókiá, her Motherhood of God. It is difficult not to believe that this is one of the examples of the general fact which I have just quoted from Dr. Bigg, and that the bishops assembled at Ephesus on that occasion were tardily conceding a demand for the recognition of the feminine principle in divinity, made even more and more openly by the voice of the common people all round the Eastern Mediterranean. We are told indeed in a contemporary letter written by one present in Ephesus at the time that the populace of the city itself, that immemorial seat of a Virgin-Goddess, gathered about the church while the Council was sitting, and put pressure on the bishops when they showed signs of wavering in their decision to proclaim the Theotókos by condemning Nestorius; and that when the decree had at last gone forth the Ephesians went wild with joy. Their Great Mother had come again to her own.

Once established, or, more probably, little by little while she was gaining recognition, the Christian Virgin appropriated the festival dates, the holy places, and even the rites of her predecessors. Here we approach a third class of survivals. The great August feast of Artemis, as I have said, became that of the Assumption of Our Lady; temples, groves, sacred springs, and other holy spots of Nature-worship were transferred to the new patroness of all life and fertility. There are hundreds of places in Anatolia, Greece, and Syria which might be called to testify. One of singular interest I visited a few years ago, that wild spot in the Lycian mountains where the ever-burning gaseous flames of the Chimæra break out in a clearing of the forest. Here, on the foundations of a temple, stands the ruin of a church built over the largest vent of the fire. Islam has decreed that the goddess of the earth-flames be no longer openly adored, but all the bushes which grow about the ruin I found hung with mouldering rags of quite modern date, witnesses that her cult is not yet dead in the hearts of shepherds and woodmen. On the wall of a ruined convent hard by is a half-effaced fresco of Mary. And for persistent rites and ceremonies let me quote once more the anointing of the great corner-stones of the ruined shrine of Paphian Aphrodite—the "Queen," as she is called shortly in inscriptions in the old Cypriote character. This observance takes place on the Feast of the Assumption of the Virgin, to whose honour, under the name Panaghiá Chrysopolitissa—the Lady of the Golden City—a church stands hard by in the precinct of the Temple. Even Moslems in Cyprus at times of stress reveal the pre-Islamic secret of their souls and bow down before the holy icon of the Virgin, painted, it is believed, by St. Luke, wafted oversea to the same Paphian shore as Venus of old, and kept by the Monastery of Kykko, and carried in procession round fields to bring rain and bless their increase. So too do they in the remoter parts of Egypt. When I was being taken over the Church of the Convent of St. Gemiana, in the marshland of the Northern Delta, I saw a woman kneeling and muttering prayers before an icon of the Virgin. It struck me she was no Copt, and I put a question to the monk who acted as guide. He shrugged his shoulders apologetically: "She is of the Muslamin," he said. "Her son is very ill. Why should she not? Who knows?"

Finally, let me return to Ephesus, whose cult with its environment I have peculiar reason to know. A phenomenon has taken place there latterly which illustrates singularly well both kinds of religious transference, the conscious and the unconscious. About fifteen years ago a Catholic priest of Smyrna who had been reading Clement Brentano's "Life of the Virgin," which is based on visions of the German mystic Anne Catherine Emmerich, and contains the story that Mary accompanied St. John to Ephesus, lodged in a dwelling at some distance from the city, and there died—a belief which we know from the French traveller Tournefort to have been held locally two centuries ago—identified the holy house with a ruined building, standing above a spring in the southern hills, and dedicated by the Orthodox Church to Panaghiá Kapouli—Our Lady of the Gate. He succeeded in buying the site and much ground about it, fenced it in, found the gardens which the Virgin had tended, and the path with its stations by which she had climbed daily to Calvary on the hill-top, and when I was there was sanguine of finding also her tomb. He proclaimed his discoveries far and wide and instituted two pilgrimages which now draw thousands of Catholics every year on the Wednesday in Easter week and in the octave of the Assumption. So far we are considering a conscious revival, located by a coincidence at the great Asiatic seat of the pagan Virgin Goddess. But there is a stranger coincidence of which the good priest was not conscious. The holy house stands far from all villages or haunts of men at the head of that same glen of Ortygia where we know, from Strabo and Tacitus, stood the original shrine of the great Ephesian Mother. It stands too on obviously earlier foundations, and, as I have said, over an *Aghiasma*, as it is called, that is, a holy spring. Indeed, very possibly it occupies the actual site of the Ortygian temple. How did this coincidence come about? On this wise. When searching the Ephesian district the Smyrniote priest asked the Orthodox peasants for places sacred to the Virgin, and was directed to this in the glen as the most holy of all. It had been, in fact, a place of pilgrimages and of intercession for the sick, for rain and fertility, and for the easy delivery of women as far back as local tradition ran. This it had been because it was Ortygia, though the villagers of Kirkinji and Arvalia knew it not. In virtue of that fact the priest appropriated it, though he never suspected the identity; and thither the faithful flock twice a year, even less aware of, but none the less compelled by, the persistent sanctity of Ortygia.

Such, then, are the religious survivals which are not survivals at all in what may be called the pathological sense, not, that is to say, elements in actual religion which have survived their utility in this system; and such should not, I urge, be treated by anthropologists without explicit reference to the fact that they are as full of meaning, as vital, and as necessary in actual cult as ever they were. They offer not so much examples of the conservatism of religion—a much used phrase of slightly contemptuous implication—as of the identity of the religious sense throughout the life of particular races and within certain geographical areas, and of the necessary conditions and limitations of its expression. They claim all the respect and tenderness of treatment due to beliefs which still make part of the foundations of our social order, and cannot be impaired or cut away, like a pathological survival, without the provision of substitutes equally efficient. Even when the rudest beliefs of primitive and simple folk are dealt with, *maxima debetur pueris reverentia*; and much, be it remembered, in the content of these great classes of religious persistences is concerned with the belief of folk who are by no means simple or primitive.

There remains, of course, an immense body of religious persistences which are more or less rightly to be regarded as survivals in the ordinary pathological sense, beliefs, observances, and rites, that is, which have indeed survived from earlier religious systems, and have lost or are losing their meaning, because they express nothing necessary or vital to the religious sense. So far as this class includes beliefs at all, these are of the kind which are called superstitions, and I venture, despite the reluctance of some anthropologists to admit a definite distinction between religion and superstition, to maintain that there is such a distinction, and that it is just this, that superstition includes only those beliefs which are held wholly or chiefly because they have always been held; which are, in effect results of earlier religious systems, or survivals in the narrower pathological sense of the word. Some religious beliefs may be survivals in the wider sense; all superstitious beliefs are survivals in the narrower sense.

The most numerous content of the class, however, is composed of observances and ceremonies. These may often persist as pathological survivals in connection with beliefs of the really religious kind. The object of cult may be a survival of the necessary and vital class, as, for example, the Virgin mother; but the particular place and manner of her worship may be conditioned by survivals of the pathologic sort. The persistence of local sanctity supplies the most obvious illustration of the latter kind of survival. For instance, while the consideration of many holy places to Christendom is due to events or traditions of Christian history itself, to connection with the Gospel story or with early preachers, teachers, or other saints, to reputed epiphanies, and so forth, a much greater number owe the fact that they are still frequented by the pious to reasons of which the pious have not the dimmest consciousness, often to features of pre-Christian Nature-worship—to rocks or springs, or even objects which may have perished long ago, like sacred trees. What Greek votary in the shrines of St. George or St. Elias could give a satisfactory account of either of those saints, demonstrate their place in the history of his Church, or say why their shrines stand in certain valleys or on certain peaks of the hills? We often know better than he; for we can say definitely that many of these saints of the Orthodox Church and of Islam, whose churches and tombs dot the Nearer East, have never died because they never lived, but are the unsubstantial shadows of old gods, clinging to the sites of shrines and groves whence their names perished long ago with the victory of the Galilean.

The particularism, which communities—village, tribal, urban, and even national—display all the world over, has had, of course, much to do with local persistence of sanctity. A small body, blessed with a private deity of its very own for uncounted centuries, who has been identified with its particular interests, and has favoured it in its multifarious local feuds, will not readily resign it for a deity of more general jurisdiction. If it accepts the Christian Virgin in place of a pagan goddess, she will be the Virgin of that particular community, unconnected with any other Virgin, and in full sympathy with the insults which Latin peasants, for example, will heap upon the Madonna of the rival village across the valley. Indeed, an indistinctive distrust of and disinclination to accept an impartial god is characteristic of all imperfect humanity, and lies beneath the sectarianism which has been promptly and continuously developed within the pale of all the great universal religions—for instance, in both Islam and Christianity. The omnipresent, omniscient Deity is too far removed, too catholic, too vague. Man ever desires to focus divine attention on a smaller area, to establish for himself some preference in the eyes of his God; and, even when most anxious to bring the rest of the world into the fold, he often most jealously reserves to his own community the distinction of a Chosen People.

This great and well-known class of observances and rites, which represent true pathologic religious survivals, supplies the bulk of the matter of all the great treatises written on cult by anthropologists, such as those, for example, of Mannhardt and Bötticher on Tree-worship, as well as others to which I have already referred, and many more. With this class the anthropologist can deal freely. In the others it seems reasonable that he should move with greater reserve; and I venture to think that he will best avoid offence if he keep clearly in his own mind, and as clearly before his readers, the main distinction between the classes of religious survivals, which, quite independently of my presentation of it, is real, vital, and of momentous significance.

SECTION I.

PHYSIOLOGY.

OPENING ADDRESS BY AUGUSTUS D. WALLER, M.D., LL.D., F.R.S., PRESIDENT OF THE SECTION.

On the Action of Anaesthetics.

THE duty laid upon me by the Chair which I have the honour to occupy to-day is in the first place to copy the example of my predecessors by submitting to the Section some distinct and definite contribution to the advancement of science.

And inasmuch as the subject has firmly held my attention during the last fifteen years, I am naturally led to name Anæsthesia as the title of my Presidential Address to the Section of Physiology.

With due regard paid to the fact that the audience to which the British Association addresses itself is not principally medical nor exclusively scientific, I shall deal with the subject in a manner that may, I hope, justify my opinion that it is a subject capable of being usefully considered by all educated minds.

And surely, quite apart from its value as an illustration of the method of physiological inquiry, the subject is one with which any educated man may well desire to possess some rational acquaintance, since every one of us may some day require the saving boon of anæsthesia.

Most people have some idea of what is meant by an anæsthetic, and will recognise by name at least one anæsthetic drug—chloroform. It is even probable that the first stranger whom you should meet in the street might also name ether and "gas" as being anæsthetics. And pretty surely he would also know that the use of an anæsthetic is to abolish pain. But if you were to tell him that a plant can be anæsthetised—that seeds can be chloroformed or etherised—he might very possibly express surprise.

The popular notion of an anæsthetic, in conformity with the literal meaning of the word, is that it is something that abolishes sensibility and takes away pain. But how, then, can a plant be chloroformed? Does that mean that a plant is sensitive and can feel pain as we do? Well, probably not; nevertheless it is very certain that a plant can be anæsthetised, and when you have properly appreciated what this means I think you will admit that our notions of vital processes and of their anæsthesia by ether, or by chloroform, or by a host of other reagents have been considerably widened. For we shall then have realised that the state of a person or of an animal rendered insensitive of pain by an anæsthetic is a particular instance of the general principle that all protoplasm—vegetable as well as animal—is liable to be immobilised—put to sleep—more or less completely—temporarily or permanently—by the action of substances which we therefore designate as anæsthetics or narcotics. A volatile narcotic, like ether or chloroform, gets to the living cells of a plant by direct diffusion; in the case of ourselves and of the higher animals it gets to the living cells by the channels of respiration and of circulation. The molecule of chloroform (or of ether) is drawn into the lungs with the inspired air, passes from the pulmonary air to the pulmonary blood, combines with its corpuscles, is thus carried first to the heart and then distributed with the blood to all parts of the body; in the capillaries the molecule of chloroform parts company from hæmoglobin, passes from the blood to the tissues and tissue fluids, and enters into combination with the living cells which it immobilises more or less profoundly, temporarily or permanently. The various kinds of living cells that constitute our organs are unequally susceptible as regards the immobilising effect of this general invasion of the system by the narcotising molecules.

Of all the cells of the body, the most labile, and therefore the first immobilised, are the master cells of the body—the cells of the grey matter of the brain, that is, the seat of sensation and the organ of voluntary motion. The most stable, and therefore the last immobilised, are the executive cells of the body that constitute muscle and nerve. The order of lability from greatest to least is as follows:—Brain; spinal bulb and cord; terminal nerve cells, cardiac muscle; skeletal muscle; nerve fibres. And while all living cells and tissues of the body are subject to the immobilising action of narcotic substances, their individual differences of susceptibility are such that, whereas one part of chloroform in 5000 of blood is sufficient to immobilise cortical nerve cells, a nerve fibre requires a more than tenfold effective mass of chloroform before exhibiting any falling-off of its normal excitability.

Let us now briefly consider what happens when a patient is anæsthetised by, say, chloroform in the usual manner by inhalation of an unknown mass of vapour. The inhaled vapour, more or less diluted in air, diffuses into, and is distributed to, the entire body by the circulating blood. The lymph bath that surrounds and permeates all the tissues and cells of the body becomes a weak solution of chloroform in water, and gradually within that weak chloroform atmosphere the most labile parts fall under the immobilising effect of the anæsthetic, first the organ of conscious sensation and movement—the cortical grey matter of the brain—then the organ of unconscious reactions, the medullary grey matter of the spinal bulb and cord. So that the order in which the effects unfold themselves are (after a brief stage of excitement or mobilisation) first a suppression of sensation and voluntary movement, then a suppression of reflex and automatic movements, inclusive of the movements of respiration. Finally—and if this finally is reached the immobilisation can no longer be recovered from—the heart stops beating. The patient is dead.

From life to death by the way of anæsthesia there are three principal finger-posts dividing the journey into three stages. Of these three finger-posts two are to be carefully watched for; the third should never be sighted.

During the first stage of anæsthesia—commencing, it may be, by some amount of preliminary agitation—sensation and voluntary motion become suppressed, while reflex and automatic movements are preserved. The finger-post between this first stage and the next is quite clear: if when the conjunctiva is touched the eye winks the anæsthesia is "light"; if the eye does not wink the anæsthesia is "deep."

During the second stage of anæsthesia not only *voluntary* but also *reflex* movements (of which the conjunctival reflex is the most convenient indicator) are wholly suppressed, while the *automatic* movements of respiration persist. This is the degree of anæsthesia required for any major surgical operation, and is therefore frequently spoken of as surgical anæsthesia. The finger-posts to its boundaries are: on this side the conjunctival reflex, on that side the movements of respiration.

The third and last finger-post—arrest of the heart's beat—should not be passed. Arrest of the pulse signifies an almost hopeless state. The time of grace between arrest of respiration and arrest of the pulse from which recovery is almost hopeless is very brief indeed—hardly more than a minute. The doctrine of the Edinburgh school—watch the respiration, not the pulse—is sound doctrine. Stoppage of respiration means danger; stoppage of the pulse means death.

I think this sketch, rough as it is, will be sufficient to bring before our minds a clear picture of the process of anæsthesia and of its principal danger—cardiac syncope. I do not wish to blur it with details. I shall therefore not enter into the question of primary cardiac syncope, nor call off your attention to other symptoms, such as the state of the pupil and the character of the pulse and the colour of the face. Nor shall I at present lay any stress upon the fact that chloroform can be of variable quality, and that like alcohol it may act differently upon different people.

First and foremost, if we are to secure the safe administration of a powerful poison like chloroform, we require to know how much of the drug is required for the production of the desired physiological effects, how much is dangerous, how much is necessarily fatal. Considering the fact that chloroform has now been in common use for sixty years,[1] and that the uniform experience of physiologists is to the effect that it is a dangerous drug as ordinarily used, it is astonishing that its administration should not rest upon any definite scientific basis.

[1] The first major operation under chloroform was performed by Sir James Simpson on January 19, 1847.

Occasional attempts have been made in the past—by Snow[1] first of all, by the French school of physiologists, Paul Bert,[2] Grehant,[3] Dubois,[4] and others, more recently by committees of medical societies and of the British Medical Association[5]—to determine what may be designated as the physiological arithmetic of chloroform; but partly by reason of the difficulty in the way of measuring percentages of chloroform in the air and in the blood, partly by reason of the facility with which chloroform can be administered without any reference to percentages, the results obtained produced very little impression upon clinical practice, and deaths that could not have occurred if the principles laid down by Snow and by Bert had been properly appreciated and acted upon, were and still are regarded by the medical profession and by the public as the normal incidents of medical practice, and attributed to any but their true cause—an overdose of chloroform.

I shall not venture to guess at the number of avoidable deaths that have taken place from this cause, but I place before you a diagram constructed from the annual returns of Somerset House and giving the number of deaths officially classified under the heading "Anæsthetics" during the last fifty years. I do not wish to use the diagram in an alarmist sense, so I hasten to call your attention to the fact that the numbers are not percentages, but absolute figures, which may in your opinion be sufficiently accounted for by the fact that the absolute number of cases has augmented in which anæsthetics have been employed, and that official returns of fatal cases may have become more complete.

Indeed, I do not myself base my judgment of the matter so much upon statistics, which are notoriously apt to be imperfect and misleading, as upon the common experience of most members of the medical profession and of many persons outside that profession; I have rarely met a well-informed person who was not personally acquainted with at least one accidental death by chloroform. Nevertheless I have presented to you the above statistical diagram because I consider that with due reservation this outcome of unprejudiced observation gives a by no means exaggerated picture of an actual fact, and because I believe it is an avoidable fact and will be diminished in future years by the wider knowledge of the physiology of anæsthesia.

I hope I shall not tax your attention too severely if I ask you to follow me through a short arithmetical argument in order to convince you that accidental deaths by chloroform must of necessity be expected to occur in the ordinary way of administration if the administrator is not fully alive to the physical and physiological properties of chloroform, and to outline in your minds a definite picture of some very simple and important measurements.

By ordinary methods of administration the percentage of chloroform vapour in the mixture of chloroform and air inhaled may be anything between 1 and 10 per cent.; let us say that it is 4 per cent.—*i.e.*, that an inhalation of, say, 500 c.c. carries 20 c.c. of chloroform vapour into the lungs. Of this 20 c.c. it is no exaggerated estimate to take one-half, or 10 c.c., as absorbed by the pulmonary blood, the other half being expelled in the expired air. If the subject breathes twenty times per minute 500 c.c. at each inspiration, his blood absorbs 200 c.c. of chloroform vapour in one minute—*i.e.*, one gram of fluid chloroform. He may, of course, absorb less than one gram per minute; but he may also absorb more. Snow estimated that 17 minims of chloroform in the blood (*i.e.*, about one gram) was sufficient to produce anæsthesia, while double the amount was fatal.

Grehant found that after death by chloroform the blood contained half a gram of chloroform per litre of blood—*i.e.*, five litres of blood, which is the normal amount in an average man, would contain two and a half grams. Buckmaster and Gardner find from numerous experiments results that may be summarised as follows:—

Quantity of chloroform (in grams) contained in 100 grams of blood:

	Min.	Mean	Max.
Taken during deep anæsthesia	0·020	0·030	0·040
Taken after death by anæsthesia ...	0·040	0·050	0·060

[1] Snow, "On Chloroform and other Anæsthetics," 1858.
[2] Paul Bert. [3] Grehant. [4] R. Dubois. [5] B.M.A.

These results signify in five litres of blood between one and two grams as the anæsthetic amount, between two and three grams as the lethal amount.

Consider, then, what might happen if a patient were to absorb chloroform at anything like the rate of one gram per minute, and what might happen if by mischance he should absorb two or three grams in a fraction of a minute. This is a mischance that can occur in the ordinary method of inducing anæsthesia: a few deep gasps by a struggling patient, a few moments' inattention on the part of an administrator, and the blood almost at once be fatally overloaded with chloroform.

In the early days of chloroform anæsthesia it used to be considered admissible to administer chloroform vapour of 4 and 5 per cent. strength in air; but at that time the means of estimating percentage were very imperfect, and the figures quoted were little better than guesswork.

The dictum of the Edinburgh school was "plenty of chloroform with plenty of air by continuous administration."

Some ten years ago, at a meeting of the Society of Anæsthetists,[1] I pleaded for the continuous administration of chloroform vapour at a strength (in air) of not below 1 per cent. and not above 2 per cent., which amounted to a translation into figures of the Edinburgh dictum, with justification of the figures by quantitative observation. Perhaps I may briefly explain the method[2] by which the percentages of chloroform and air are obtained:—

	Grams
A litre, or 1000 c.c., of chloroform vapour weighs	5·333
A litre, or 1000 c.c., of air weighs	1·288
The litre weight difference is therefore	4·045

The weight difference of 1 c.c. is approximately 4 milligrams.

So that a 100 c.c. flask in which 1, 2, 3, &c., c.c. of air are replaced by 1, 2, 3, &c., c.c. of chloroform vapour is 4, 8, 12, &c., milligrams heavier than the same flask filled with air.

So that added weights of 4, 8, 12, &c., milligrams indicate 1, 2, 3, &c., per cent. of chloroform vapour present.

Thus, by simply counterpoising a 100 c.c. flask (or, preferably, a 250 c.c. bulb, so as to give weight increments of 10, 20, 30, &c., milligrams as indications of 1, 2, 3, &c., per cent.) filled with air against a similar bulb filled with chloroform mixture, the percentage of the mixture is read directly by the number of centigrams required to counterpoise. For instance, a bulb full of mixture being, say, 18 milligrams heavier than when it is full of air, the chloroform vapour percentage is known to be 1·8 per cent.

Evidently, with a ready means of estimating percentage, one is entitled to talk about the percentages that one considers from experiment to be necessary and sufficient and excessive.

My argument up to this point comprises one or two tacit assumptions that ought to be briefly dealt with, or, at any rate, mentioned.

In the first place, I have assumed that the great majority of accidents by anæsthetics are caused by chloroform.

This is accounted for by the fact that chloroform is the most powerful, the most convenient, and the most extensively used of all anæsthetic vapours. I hasten to add that, in my opinion, this fact is an argument not so much for the substitution of other less dangerous anæsthetics as for the more careful administration of chloroform itself.

In the second place, I have assumed that chloroform is a remarkably uniform and certain reagent, producing its physiological effects in strict conformity with the quantity of vapour administered, and by no means irregular in its action by reason of irregularities or impurities of manufacture. Pure chloroform is more powerful than impure chloroform.

I do not dwell upon these two points now; nevertheless I should like to say that these are not gratuitous assumptions, but, more properly speaking, results of observation

[1] Waller, *British Medical Journal*, April 23, 1898.
[2] Waller and Geets, *ibid.*, June 20, 1903.

and experiment, of which I can offer some evidence. I have tested purified chloroform against the concentrated residue of its impurities, and have found the former to be far more powerful than the latter. And I have compared with each other chloroform or trichlormethane, $CHCl_3$, dichlormethane, CH_2Cl_3, monochlormethane, CH_3Cl, tetrachlormethane, CCl_4, as well as many anæsthetics of the ether group, Et_2O, EtCl, EtBr, EtI, and several anæsthetics belonging to the series of chloroethanes, members of which have at various times been recommended as substitutes for chloroform—*e.g.*, ethylene chloride or "Dutch liquid," $CH_2Cl—CH_2Cl$, and ethylidene chloride, $CH_3—CHCl_2$. The conclusion I have drawn from this study is that of all these more or less powerful anæsthetics chloroform is the most powerful, the most certain, the most convenient, and the most trustworthy.

But I would repeat the statement that the safe administration of chloroform consists in its continuous administration at a strength of between 1 and 2 per cent. And if anyone now objects that it may be safe to go up to 3 per cent., or sufficient to go down to ½ per cent., I am content to accept the objection as being possibly well founded, because it carries with it the all-important admission that the question of safe anæsthesia is in first instance a question of quantity, and in second instance a question of idiosyncrasy and of clinical conditions.

Admitting, then, that the primary condition of the safe administration of chloroform consists in the continuous administration of an atmosphere in which chloroform vapour is between the limits of 1 and 2 per cent., the question is how best to secure this essential condition. It can be secured by many methods. Given the requisite care, skill, and experience on the part of the administrator, anæsthesia may be properly carried out by any method, empirically or otherwise. But some methods demand more skill and care than other methods, and the task of the anæsthetist may be lightened (or it may be aggravated) by various mechanical appliances. A folded towel drenched with chloroform may be safely used by an anæsthetist whom previous experience has rendered fully alive to the extreme danger of two or three deep inspirations of a concentrated vapour, and whose attention is never distracted from the paramount necessity of "plenty of air" with the "plenty of chloroform." On the other hand, a person unmindful of the physiological elements of chloroformisation is a dangerous administrator if he is content with the empirical use of any apparatus, however faithfully he may carry out the instructions of his instrument maker.

Methods and apparatus are legion, and it would be futile or invidious on my part to attempt to describe or criticise in detail any one method or apparatus. But I may usefully invite your consideration of certain principles and ask you to recognise that for their trial by experiment the chief necessity is a simple method, such as I have just described, enabling us to test percentages quickly. Thus, by the use of this method, Mr. Symes[1] has determined what are the usual percentages of chloroform vapour offered to inspiration by an ordinary Skinner's mask, and found them to range between the desirable limits of 1 and 2 per cent., with occasional fluctuations up to about 3 or 4 per cent.

All apparatus designed for the delivery of chloroform vapour of definite and controllable percentage is based upon one or other of two principles. On the first or vacuum system, of which the best known examples are the apparatus of Snow and that of Harcourt, the patient inspires air through a vessel containing liquid chloroform by a broad inlet tube and a closely fitting face-piece.

On the second or plenum system, of which the examples best known to me are the apparatus of Dubois and that to which I have given the name of the "wick vaporiser,"[2] the patient inspires from a freely open face-piece in which an excess of chloroform and air at required percentage is maintained by a pump.

In my opinion, if apparatus is to be adopted, the plenum is preferable to the vacuum principle: for in the latter case it is more difficult to secure uniformity of administration, which requires a perfect fit of the face-piece, stillness of the chloroform over which the inspired current of air is drawn, and which causes of necessity a considerable added resistance to inspiration. By the plenum system there is a more uniform percentage of supply, and the patient breathes freely from an open loosely fitting face-piece, the cavity of which is kept filled to overflowing by an excess of mixture of controllable strength.

But, whichever of these two systems be followed, the choice is obviously one that can only be determined by experience, both clinical and of the laboratory. Equally obviously the so-called accurate percentages afforded by any method can only be approximately accurate under the sometimes difficult conditions of practical administration, and it is therefore of principal importance to ascertain by a simple and ready method of estimating percentages such as I have described above what is the degree of accuracy, or, if you prefer to say so, the range of inaccuracy to which any method or apparatus is subject under the ordinary conditions of its application.

You may indeed sometimes hear it said that the percentage can be judged of by the sense of smell, which therefore affords the readiest means of estimating the strength of a mixture, to which I should like to add yes, certainly, provided the observer by previous experience of known percentages has formed some standard of comparison on which his opinion is based.

I have finished what I set myself to say to-day concerning the physiological problems involved in the question of safe anæsthesia by chloroform.

But I have reserved for my conclusion certain considerations by which it is customary to introduce the particular subject under review. May I briefly trespass further on your attention to say something about the conditions under which physiological inquiry is pursued in London?

Physiology, in the technical and restricted sense commonly received in this country, has become so closely associated in the public mind with vivisection, and, as dealt with in the medical curriculum, is so narrowly reduced to what is strictly necessary and practicable, that its real scope and value as a general science have been altogether lost sight of.

I do not propose on the present occasion to deal with the question of vivisection either on its ethical or on its utilitarian aspect. All I wish to do is to bring distinctly before your minds two considerations that may, I hope, contribute to a broader and truer conception of the place of physiology among the sciences, though they assuredly will not justify the claim of Dubois-Reymond that physiology is the queen of the sciences.

The first of these two considerations is that the province of vivisection, essential as it is, is a very narrow and restricted province indeed in the domain of physiology. In the ordinary routine of the physiological laboratory experiments involving vivisection are infinitely less numerous and infinitely less exacting than experiments that involve no vivisection. Vivisection is, in fact, an infinitesimal fraction of experimental physiology, whereas in the minds of many who should know better experimental physiology always means vivisection: the two terms are taken as synonymous, and an odium that should not have been attached either to physiology or to vivisection has been directed through vivisection upon the whole of physiology. Yet do not mistake my meaning. I do not for one moment surrender the claim that upon ethical and utilitarian grounds vivisection is lawful; I deprecate the perverted picture of vivisection that is presented to public opinion by sensational agitators and the perverted notion of physiology that is one of the evil results of the anti-vivisection crusade. But I do not desire to dwell on the vivisection question; I do not consider that it can be usefully considered by the general public without an intimate knowledge of the subject, itself possible only to the specialist. An ordinary normal person who should say he approved of vivisection would be, in my opinion, even more objectionable than an ordinary normal person who should express a detestation of vivisection, for the bare idea of vivisection is repugnant to every humane person. To bring dispassionate argument against such natural repugnance seems to me hardly less mischievous than to fan repugnance into hatred by passionate appeals to the

[1] Symes, *Lancet*, July 9, 1904.
[2] Waller, Proc. Physiol. Soc., August 19, 1904.

imagination. The surgeon to whom an ignorant crowd should impute cruelty would fail to serve the cause of humanity by the technical descriptions to them of the operations he is required to perform.

There are two great principles involved in the welfare of any applied science—in the welfare indeed of any living thing—the conservative principle and the progressive principle.

Any organised living mass—let it be an animal or an organised body of men—by virtue of the conservative principle of heredity, of repetition of like by like, of imitation of action that has proved to be successful, works more economically than it could have done if each individual mass had perforce to work out its own salvation, evolve for itself its own suitability to and temporary mastership of surrounding circumstances.

But the child that can only imitate and repeat the actions of its ancestors brings no positive addition to the excellence of the race the upward progress of which requires to be fed by the costly process of initiative efforts, by the sports of talent and of genius, by the cumulative effect of innumerable hits among innumerable misses of innumerable multitudes of individuals.

Transfer this thought to education—to medical education in particular. An educated person—a competent physician or surgeon—must in the first place learn at the feet of his masters, believe and learn what he is told, imitate what he sees done by his instructors, be the apprentice and follower of the experienced craftsman who shows him tried and approved ways of working.

But the apprentice who is to contribute to the commonwealth of knowledge and power has to be something more than the faithful imitator of his teacher; he must initiate, and he must make a hit among, it may be, his many misses. He will then have contributed to the advancement of knowledge and power.

In all provinces of human activity we may distinguish the result of our two complementary principles—imitation, the conservative principle; initiation, the progressive principle. But while in all provinces the conservative factor, being, so to speak, the means of wholesale economy, bulks the larger, the progressive factor, as the means of retail economy, is relatively insignificant.

Between the two extremes—imitation on the one hand, initiation on the other—there is room for numberless variations; and, by reason of the vastness of area of even the minutest province of human activity, the aim of education, even the most technical, is perforce more and more directed to teach the pupil to use his own mind in presence of the task set him rather than to copy minutely and to reproduce perfectly the model facts shown or described to him by the master.

But in every province, and in particular in that of education, the power of imitation is easier to exert and easier to develop than the power of initiation, which is a rare and costly ingredient, since at any given juncture the odds must be heavily in favour of the success of the time-honoured fact or method as compared with its yet untried competitor.

There are of necessity many misses and few hits among the novelties that come to trial.

The genius of our nation is admittedly a practical genius that looks upon the conservative way as the better way, and makes its changes by as small steps as can be from precedent to precedent. This is the safe and easy way, the way of nature; and to this predominance of fact copied over fancy realised may fairly be ascribed our own prolonged constitutional prosperity. We have found by long experience that it is very long odds indeed against any dark horse without a good pedigree of precedents, so we prefer to back the field; old methods are the safe thing and the good thing.

But one may have too much of a good thing, and in education I think we have had too much of the old methods, in which the keynote is imitation and examination of copy, and too little of that expensive and dangerous ingredient—so dangerous that to some authorities it appears in the light of a poison—initiative and originality of thought. I admit all the danger; I grant to the old authorities that there is a good deal of trash current under the label of original research. But I do not think we can have wheat without chaff, and I am convinced that the adherents of original research, as against the *clientèle* of the examiner and of the crammer, bring to the educational commonwealth the scanty and much needed ingredient of initiative. We want education still further urged in the direction of teaching the pupil to use his own mind upon unseen translation of new facts into effective conduct, and one of the best ways of obtaining that the teacher shall guide his pupils to use their own minds is that he should himself use his own mind, and not suffer himself to drop into the jog-trot of routine. We want our teachers to be learned men, but we also want them to continue to be learning men; and that is why, in spite of its defects, I want to urge that greater encouragement be given to original research.

I hope I shall not have taxed your patience too far if I bring these considerations to their natural conclusion by telling you as briefly as may be of an effort that is now being made in the University of London to strengthen and organise that spirit of initiative which is, I am convinced, of capital importance in all teaching, the most elementary no less than the most advanced. We have formed ourselves into a school of physiology, including every teacher of physiology in London, each of whom undertakes to give at the headquarters of the University lectures upon those portions of the science with which his own previous study has rendered him specially conversant. The teaching offered is of an advanced character, and is addressed more especially to post-graduate and to Honours students; and, in pursuance of the principle that such teaching is the immediate consequence of learning, the University has provided a research laboratory in which teachers and other post-graduate students find the necessary facilities for work. We believe that the experience of the last five years has sufficiently proved that a "college of learning" thus constituted renders valuable assistance to the teachers and students of the schools of London, and that it is helping to draw to a focus resources and efforts that are at present scattered and wasted among the several schools. I cannot do better in this connection than quote the words of the Chancellor of the University (Lord Rosebery):—"We hope to make this laboratory the central spot for medical research in London . . . an institute of studies ancillary to medicine, which may develop and complete the work of the University in that direction." And I think that you will agree with me that any movement that contributes to the good health of the University of London contributes to the good health of every university in the Empire, and of every school the teachers of which are animated by the university spirit—the love of learning for its own sake as well as for the sake of the mental and material power that is required of us.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The mastership of Downing College has been offered to Prof. Howard Marsh, who has, it is understood, given a favourable reply, but the election cannot take place until October.

Mr. Augustine Henry has been appointed reader in forestry for five years.

A university lectureship in botany will be vacant at Michaelmas in consequence of the resignation of Mr. Hill. The annual value of the post is 100*l*. Applications for the lectureship, accompanied by testimonials, should be sent to the Vice-Chancellor on or before October 11.

LONDON.—Dr. E. A. Westermarck has been appointed to one of the two professorships of sociology founded by Mr. Martin White—the one for five years; the appointment to the permanent professorship has not yet been made.

Dr. A. C. Haddon, F.R.S., has been appointed university lecturer in ethnology for the session 1907–8 under the Martin White benefaction. The teaching in these sub-