The regions of Virginia surrounding the Chesapeake Bay probably produce more early potatoes than any other part of the eastern States, the annual value of the crop approaching 6,000,000 dollars. Little damage is caused by blight, but the Colorado potato-beetle (*Leptinotarsa decemlineata*, Say) is a serious pest, and only very crude methods are adopted for keeping it in check, because of the prevalence of negro labour and the scarcity of capable white help. Mr. Popenoe gives a description of the pest and of the damage it does, and describes experiments in which three applications of lead arsenate mixed with Bordeaux mixture, the first about the time the eggs begin to hatch, and the others at intervals of three weeks, sufficed to control it.

Some new breeding records of the coffee-bean weevil (*Araecerus fasciculatus*, De Geer) are published by Mr. Tucker. He found the larval and pupal stages in some dried maize stalks, and obtained evidence that the insect causes injury to the maize plant. The attacks begin in the green stalks before the corn matures, and thus cause stunted ears. This weevil has also been found in the berries of the China berry tree.

Stringent laws are in operation in most of the States with regard to the importation of nursery stock. It is commonly necessary to notify the State entomologist within twenty-four hours of the arrival of the stock, and to fumigate satisfactorily. The laws of the different States are not all alike, and Mr. Burgess has collected in a short pamphlet the requirements which must be complied with by those making inter-State shipments of nursery stock. The pamphlet will form an interesting study for those who are agitating for some State supervision in this country.

THE METHODS OF MATHEMATICS.[1]

THE position assigned to mathematics in the educational system of every civilised country seems to mark it out as an essential element of mental culture, but an examination of the arguments that have been put forward from time to time to justify this position reveals a diversity of view that is at first sight disquieting.

Of those who acknowledge the value of mathematics there are many who see that value almost solely in its usefulness, in the help it brings to other sciences. Not unnaturally, those who are absorbed in the work of applied science are apt to turn away from the more abstract developments of modern mathematics; even the men whose special pursuits call for constant applications of mathematical processes, as in physics and engineering, can hardly be blamed if they lay special emphasis on those elements of a mathematical training that are of immediate application to their daily work. Yet it is not this aspect of mathematics that is usually present to the professional mathematician when he seeks to uphold the position of his subject in an educational system.

Mathematics may be assigned its place for a different reason. To those who reject the argument from utility, mathematics is not the humble auxiliary of other sciences, but is itself the one genuine science; it often comes to the aid of other sciences, but does not depend for the justification of its existence on the help it may be able to bring. From the adherents of this view come the familiar arguments for the disciplinary value of a mathematical training in which deductive logic is given a prominent place.

The question naturally arises whether these two aspects of mathematics are incompatible. To the teacher, whether in school or in college, the question is of prime importance; for the whole scheme of study and the methods of instruction will be found in the long run to be determined by the general attitude that is taken up with respect to the value of the subject. At the present time there is considerable uncertainty in the minds of teachers regarding the methods of school mathematics, and many of the older men are disposed to look unfavourably on recent changes as tending to impair the disciplinary effects of a mathematical training.

It may help us to understand more clearly the points at issue if we consider for a little the trend of mathematical inquiry during the nineteenth century. It is not necessary that I should sketch even in the roughest outline the development of mathematical science in that period; it will be sufficient for my purpose to indicate one dominant feature of the mathematical methods that were introduced in the early years of that century and that revolutionised the treatment of pure mathematics before it had reached its close.

During the eighteenth century the infinitesimal calculus and the doctrine of infinite series enabled mathematicians to investigate problems, intractable by the older methods, with a facility that led to a wide extension of the field of mathematical inquiry and to an enormous accumulation of results. In this period interest was centred less in demonstrations than in results, which were often reached by methods of a strange character, and sometimes, indeed, seem so absurd in themselves that we find it hard to understand how they were ever promulgated. Induction played a most important part in the discovery of theorems, and these inductions were often made from insufficient data and too seldom verified by subsequent tests. When the novelty of the processes had worn off, the necessity for a critical examination of their legitimacy became evident, and this examination was one of the tasks of the nineteenth century. It should be noted, however, that the great critics were also great creators; the criticism of the methods of mathematics was accompanied by a wide extension of its domain.

Of those who first saw the necessity for criticism and set themselves to the task were Gauss, Cauchy, and Abel. Gauss was first in the field, but, for various reasons, his work was long neglected. It was not until the publication in 1821 of Cauchy's "Cours d'Analyse" that the attention of mathematicians was effectively directed to the question.

Geometry in the hands of the Greek mathematicians had been reduced to a system of logically consistent truth; from assumed definitions, axioms, and postulates the various theorems of geometry were derived by the methods of formal logic, and Euclid's "Elements" were for centuries the standard of mathematical rigour. Algebra, or, in modern terminology, analysis, was of much later growth, and Cauchy's reference to the rigour that is demanded in geometry simply means that the time had come when the revision of principles and methods that the Greek mathematicians had effected in geometry should be carried out for algebra or analysis. The eighteenth century was a period of great activity in the development of analysis, and it is not surprising that the pioneers of this development should have been more interested in the resources of the country they were opening up than in the roads they followed. Their methods of mathematical inquiry were not limited by the traditional canons of Greek geometry; they included induction as well as deduction, there was constant appeal to intuition, and general theorems in mathematics were often established from physical considerations. The usefulness of mathematics as an aid in the investigation of the phenomena of the material world was the predominating feature of the period. The aim of Gauss, Cauchy, Abel, and their coadjutors was, in general terms, to do for analysis what the Greeks had done for geometry, and to make mathematics an independent science by clearly defining its province, stating the postulates from which the science starts and developing the consequences by the laws of logical operation without appeal to extraneous considerations.

The work of scrutinising the methods of analysis was vigorously pursued throughout the nineteenth century, and exerted a far-reaching influence. The notion of continuity, which seems so naturally to attach to geometrical quantity, required to be formulated in such a way that it would be amenable to calculation. Current conceptions of number were too vague, and it was found necessary to analyse more carefully the notion of numerical quantity so as to frame definitions and to establish rules of operation for the continuous variable of analysis. The so-called imaginary numbers had been long in use, but their existence was of a precarious nature, and the right to use such numbers had to be justified.

As will be easily understood, many of these discussions are of a very abstract nature, but they have provided a

[1] From the inaugural address delivered on October 11 by Dr. George A. Gibson, Professor of Mathematics in the University of Glasgow.

solid foundation for the operations of mathematics, of geometry as well as of analysis.

The movement, however, was not without its disadvantages. Mathematics gradually became more and more abstract, and the relations of mathematics to the applied sciences tended to fall into the background. On one hand it was manifestly impossible for the physicist and the engineer to keep themselves abreast of the developments of pure mathematics; on the other, the rapid extension of physics and engineering made it difficult for the mathematician, even when he had the desire, to understand the problems in the investigation of which mathematics might have been useful. The mathematics of the secondary schools was not affected to any considerable extent by the critical movement, but it probably became more formal and lost contact with the applied sciences.

Towards the close of the century complaints were rife, especially among the engineering community, that mathematics had lost touch with reality, and demands were made for a radical change in the mathematical training of the schoolboy. The feelings of dissatisfaction were not confined to any one group, and men who represented the most widely separated interests took a keen and active part in the discussions. Many of the views expressed respecting the methods of mathematics were far from new, but the emphasis with which they were urged may perhaps be taken as an indication of the extent to which, in the opinion of many competent judges, the deductive element in mathematics had overshadowed all others.

It may be conceded that, in the claims that have often been advanced for the efficiency of mathematics as an educational instrument, far too much has been made of the deductive aspect of mathematical studies; but in view of what has been said about the character of eighteenth-century mathematical methods, the assertion that mathematics knows nothing of induction is surely inaccurate. It is besides, I believe, a complete misunderstanding of the critical school to suppose that induction is barred as a mathematical method. By induction I do not here mean simply what is called "mathematical induction" or that method of demonstration which shows that if a theorem is true in one case it is true for the succeeding one; I am using the word in the sense it generally bears in speaking of scientific method. Induction as a method of discovering new truths or generalising known theorems has always been recognised to be of very great value, and is in constant use in advanced as well as in elementary mathematics. The critical objection to it was solely in respect of its use in a *systematic* development of mathematical truth (Euclid's "Elements," for example, embody a systematic development of geometry in which the theorems are linked together by a chain of deductive reasoning). As Weierstrass, one of the greatest of the critics, says, "it is a matter of course that every road must be open to the searcher as long as he seeks; it is only a question of the systematic demonstration."

In any discussion of mathematical methods it is important to bear in mind that the conviction of the validity of a theorem is not dependent on any single method of proof, even though one may strive to furnish a demonstration that conforms to some prescribed system. In mathematics, as in other sciences, conviction comes from many quarters, and one might almost say that where higher mathematics enters into the work of the physicist or the engineer the conviction that comes from the logical consistency of a mathematical demonstration is less important than the conviction that is due to insight into the physical facts and to the perception of the correspondence between the mathematical representation and the data of experiment. I think that pure mathematicians have not always given due weight to the instinct of the trained experimenter, and that, for the physicist, the true source of the conviction of the validity of "existence theorems" is often to be found in the disciplined imagination rather than in the cogency of the mathematical analysis. On similar grounds the essential accuracy of many of the results obtained by eighteenth-century mathematicians may be explained; their practical instincts prevented them from pushing a theory or method too far.

Now if it be granted that induction is a recognised mathematical method, it is hard to understand how observation and experiment can be dispensed with, because these are essential preliminaries to induction. In the development of mathematical knowledge it is quite certain that the predominance of deductive methods was of comparatively late growth, and that in the earlier stages observation played the leading part. It is unfortunate that so little of the work of the early Greek geometers has been preserved, but it is undoubtedly the case that geometry in its beginnings was essentially surveying or mensuration, and many of Euclid's theorems were known long before they were incorporated in a systematic treatise. There was, in fact, a "natural history" stage in the development of scientific geometry which the perfection of Euclid's deductive treatise has tended to obscure. The stage in which geometry appears as a logically consistent system was preceded by a period in which geometrical theorems were discovered as the result of observation and the consideration of many particular cases; in this formative period induction based on observation had full scope.

The evolution of scientific algebra has followed similar lines. The introduction of fractions in arithmetic, for example, and of negative and imaginary numbers in algebra, was due to their convenience in handling practical problems; the rules for their use were usually established, so far as proof was considered necessary, by appealing to numerous particular cases. The logical consistency of the scheme of operations was seldom discussed; so long as a rule led to results which gave a solution of the particular problems under investigation the need for a systematic presentation was not even felt. This stage —the "natural history" stage—of the development of algebra is well known to us by the works that have been preserved of the early writers on algebra; it would perhaps be true to say that a great part of elementary algebra has not advanced in actual school teaching beyond this stage.

The advance of mathematics to the position of a logically consistent system of truth has thus been governed by the same principles as regulate the progress of every science. Induction based on observation and confirmed by tests or verifications was constantly employed in extending the range of the science, and it was only gradually that deduction became the predominant, though never the exclusive, method of mathematical study.

In the recent discussions on elementary mathematics the guiding principle that has emerged seems to me to be the explicit recognition of the essential part that observation and induction play in the acquisition of mathematical knowledge. With this recognition is associated the idea that in the early training of the pupil it is scientifically unsound and practically hurtful to emphasise the deductive element; his training should, in its broad outlines, be modelled on the course that the historical development of mathematics has followed. Mathematics has now reached the stage in which it is possible to treat it as a deductive science, but it does not follow that it is either necessary or possible to teach it to beginners entirely as a deductive science. To do so is to mistake the meaning of its history and to deprive it of its place as an exponent of scientific method. Observation, classification, and induction are essential elements of scientific method, and these are well illustrated in the historical development of mathematics. The recent discussions have shown that, in the opinion of many experienced teachers, it is not only possible, but necessary, to make full use of these methods in mathematical teaching, and the conviction is widely held that they are of special importance in geometry, the branch of elementary mathematics where deduction has so long had the leading place. The excellence of the intellectual discipline to be obtained from a study of Euclid is, in my opinion, not to be questioned; but I think there is no doubt that it is contrary to all scientific order to take Euclid as our guide for an introduction to geometry. It is necessary for the pupil to acquire a knowledge of the forms of material objects before he can reasonably be expected to demonstrate the geometrical properties that are implied in the definitions of geometrical bodies. In acquiring this knowledge observation and classification are essential, and deductive reasoning will have little place. The knowledge thus gained may be quite entitled to the name of scientific; if the course is carefully planned and carried out, it will be quite possible to obtain a system that is not a mere aggregate of isolated details, but a coherent structure. The importance of a practical course is now generally recognised in its bearing on deductive geometry; its value, however, in relation to the appreciation of scientific method is equally great.

The early stages of algebra are usually found to be very difficult, and are too often of little scientific value; the subject is more abstract than geometry, and the temptation to let the teaching degenerate into a mere mechanical application of rules is very great. I cannot but think, however, that the spirit of De Morgan's chapter on "The Study of Algebra" in his book "On the Study and Difficulties of Mathematics," written so long ago as 1831, is in full accord with scientific method, and is worthy of being more completely realised in practice than it has yet been. I cannot refrain from quoting a few sentences that indicate his view of the way in which a reasonable conviction may be obtained. After pointing out the value of *mathematical* induction, he says:—"The beginner is obliged to content himself with a less rigorous species of proof though equally conclusive as far as moral certainty is concerned. Unable to grasp the generalisations with which the more advanced student is familiar, he must satisfy himself of the truth of general theorems by observing a number of particular simple instances which he is able to comprehend. For example, we would ask anyone who has gone over this ground whether he derived more certainty as to the truth of the binomial theorem from the general demonstration (if indeed he was suffered to see it so early in his career), or from observation of its truth in the particular cases of the development of $(a+b)^2$, $(a+b)^3$, &c., substantiated by ordinary multiplication. We believe firmly that to the mass of young students general demonstrations afford no conviction whatever; and that the same may be said of every species of mathematical reasoning when it is entirely new."

There can, I think, be no doubt that it is now generally recognised that it is in accordance with true scientific method to keep the purely deductive element in the background so far as the early training in mathematics is concerned, and that by so doing the general methods characteristic of scientific procedure are more fully illustrated. This recognition, however, does not imply that the characteristically deductive side of a mathematical training is to be neglected; it means rather that deduction, which is surely a scientific method, will be used with a fuller comprehension of its place and even of its necessity. The time and the manner of the passage to deduction are not to be easily decided; much depends on the pupil, and it is one of the hardest tasks of the teacher to determine the appropriate correlation of methods. Induction is essential as an instrument of research, but deduction is also essential to the systematic development of mathematical science, and no training in mathematics can be considered satisfactory that does not show the complete process by which mathematical knowledge advances from the stage of observation to that of a science in which deduction plays the principal part in the coordination of its contents.

In this conception of elementary mathematics we have the leading characteristics of scientific method, and have them, as I think, in great simplicity. It is on this ground that the study of mathematics seems to me to be a valuable, if not indeed an essential, factor of modern education. Science has effected a great revolution in the material conditions of life, but it has also produced a profound change in the mental attitude of all thinking men. Our civilisation is not intelligible unless account is taken of the influences, material and intellectual, that are due to the progress of science. The right study of mathematics, even in its humblest forms, offers an easily accessible road to the appreciation of the fundamental characteristics of scientific method.

It is of interest to note further that the more recent methods of treating elementary mathematics, which are inductive rather than deductive in their character, lead in a natural manner to an appreciation of some of the cardinal ideas and methods of pure mathematics. Thus the notion of a continuously varying function, the conception of a limit and the method of successive approximation, cannot fail to be impressed upon a pupil who has been adequately disciplined in graph tracing.

The complexity of the problems confronting modern scientific research, with the vast accumulation of detail so characteristic of it, demands a careful training in the discrimination of the essential from the accidental, in the search for the underlying principles that coordinate or explain the details, and in the selection of the most general points of view from which to survey the field that has been worked. In this training, quite apart from the direct utility of the more advanced mathematical processes, much assistance is to be obtained from a mathematical course; the processes of thought involved in any serious study of mechanical or physical phenomena have much in common with those developed in the study of mathematics. It is the special task of the teacher to determine the extent to which the rigorous methods of pure mathematics are to be carried. Rigour is relative, not absolute, and will always be conditioned by circumstances of subject and person, and even by the prevailing fashions of the day. Restrictions corresponding to the nature of the subject and to the intellectual development of the student have always been recognised as essential. Many assumptions are either tacitly or explicitly made, fundamental theorems the demonstration of which offers special difficulty are frankly taken for granted until the necessity or the expediency of their demonstration arises and the logical completeness of a course is therefore impaired; but progress is all but impossible on any other lines, and much may be gained from demonstrations that are in parts confessedly incomplete. The real danger to the student lies in a demonstration that has the appearance of being complete and yet conceals serious assumptions. It is a great advantage that in mathematics general theorems can often be tested by particular cases that are easily handled, and practice of this kind will often produce that working conviction which is so essential for fruitful applications. One is reminded in such cases of the saying attributed to D'Alembert, "Go forward and faith will come to you."

Up to this point I have been considering the methods of mathematics almost solely in relation to the function of mathematics as a factor of general education or as the auxiliary of the applied sciences in their more elementary stages. The considerations that I have thus hastily sketched seem to me to involve the conclusion that this phase of mathematics is to be justified neither by its usefulness alone nor by its disciplinary power alone, but by the degree to which the training combines these elements. In a properly balanced mathematical course the characteristic features of scientific method will receive due recognition, and the mental horizon of the learner will be gradually enlarged; but the choice of material and of method will prepare him for the application of mathematical processes in various fields, and the study as a whole will powerfully react on his mental development.

It must not be forgotten, however, that the claims of mathematics are not exhausted by such developments as I have indicated. I have deliberately avoided all reference to what is called pure mathematics, and have confined myself to those aspects of mathematical study that are of general interest. It is difficult for anyone who is not a professed student of mathematics to realise the position of the subject in its modern developments. The great critics of the nineteenth century were not less successful in extending the boundaries of mathematical science than in securing by a just title the territory acquired, and to-day the range of subjects that fall properly within the domain of mathematics has an extent that the contemporaries of Newton and Leibnitz never dreamed of. As the result of their labours mathematics ranks as a science worthy of cultivation for the intrinsic value of the conceptions which it embodies, for the appeal it makes to the constructive imagination, for the light it casts on the processes of thought, and for the inherent beauty of form that characterises many of the theories comprised within its domain; but any attempt at reviewing, within the limits of time allotted to me, the present state of the science would certainly fail to give any adequate conception of the nature of its contents. To the mathematical student, however, the assurance can be given that he need not fear that the science is complete and that all the problems it presents have been finally solved. Abstract as these investigations often are, there is ample room for the application of those general principles of scientific research which his earlier training will have helped to develop, and the final test of his mathematical powers will be found in the success with which he extends the scope and methods of the science.

Mathematics as we know it to-day is in living contact with experimental science on the one side; on the other it borders on the domain of philosophy; to each it has some contribution to offer, and in the words of Weierstrass "a mathematician who is not something of a poet will never be a complete mathematician." Is it not, then, a subject worthy of a place in university studies?

DEVELOPMENTS OF ELECTRICAL ENGINEERING.[1]

THIS address deals with a few only of the many recent developments in electrical plant and its application to industrial purposes.

Generators.

The modern tendency is to instal very large units. This is partly due to the large demand made on the power house and the desire to restrict the number of units, and partly to the fact that the advantages of the steam turbine over the reciprocating engine become more pronounced with the increased size of the unit. The General Electric Company of New York have built several turbo-alternators of 14,000-kw., and the British Westinghouse Company inform me that it would be quite feasible to build sets of 15,000 kw. up to 15,000 volts pressure. In water-driven alternators, also, the tendency is towards large units. Thus the power house of the Norwegian Nitrogen Company at Svälgfos, near Notodden, has been fitted with four turbine-driven three-phasers, each for 10,500 kilovolt-ampere, and developing 7000 kw. at 10,000 volts. It is obvious that in these circumstances special ventilating arrangements become necessary. Dr. Kloss, in a paper read before our Institution about a year ago, has pointed out that the scientific way of ventilating turbo-dynamos is to take the air from the outside and discharge it to the outside of the engine-room. It is important that only clean air be used, and for this reason air filters are built into the inlet ducts. These are formed of pockets of porous cloth extended over wooden frames, and so placed that the dust which settles on the cloth may be removed by beating or with a vacuum cleaner. Washing or chemical cleaning is only required after some years of use.

In most modern electricity works the circulating and air pumps are driven by electric motors, but this method has been replaced at the works of the Allgemeine Elektricitäts Gesellschaft by turbo-driven centrifugal pumps. No piston pumps at all are used, and the feed may be regulated without paying attention to the feed pump. The feed water obtained by this method is absolutely free from air, and only 5 per cent. of make-up for the feed is required. Since no piston engines of any kind are used, there is no need for oil filters.

An important development in turbo sets was initiated about ten years ago by Prof. Rateau with his exhaust steam turbine. The cost of adding exhaust steam turbo sets to an existing installation of large size may be taken at from 6*l.* to 10*l.* per kilowatt exclusive of thermal storage. The commercial advantage is considerable. Thus in the Osterfeld Mine a Rateau plant installed at a cost of 53,000*l.* has resulted in an annual saving of about 20,000*l.*

The desire to reduce the cost and complication of switch-gear and to make paralleling easy has led to the use of non-synchronous machines as generators. The rotor may be a squirrel-cage of very simple construction and requiring hardly any insulation, no matter how high the pressure produced by the stator may be. The mechanical construction is easier than that of the revolving field of an ordinary turbo-alternator, and since the air space can be made small, the power factor is high. A 5000-kw. non-synchronous generator was last year added to the plant of the Inter-borough Rapid Transit Company, New York.

There is some difficulty in the design of turbo-alternators for very low periodicity, since the speed becomes insufficient for the satisfactory working of the turbine. To meet such cases Mr. E. Ziehl has devised a type of alternator which he calls a "double-field generator." The principle may be explained as follows: Imagine a non-synchronous motor having precisely the same three-phase winding in stator and rotor, and let the circuits be connected either in series or parallel in such way that a three-phase current sent through the machine will produce fields which in stator and rotor revolve in opposite sense. If now the rotor be driven by power in a sense opposite to that of its own field and with a speed corresponding to twice the frequency, the field produced by the rotor currents will in magnitude and direction of motion be identical with that produced by the stator currents. Thus each of the two windings contributes one-half the field common to both. At the same time the demagnetising action of each winding is eliminated by that of the other. Since the E.M.F. is generated in both windings, only half the flux as compared to a synchronous generator is required; hence less hysteresis loss, smaller radial depth of stampings, and less copper weight. The paralleling is easy; the speed need only be approximately right, and if coupled up in a wrong phase position no damage is done, since the inductance is then very great.

Transformers.

In transformers also there is to be noticed a general tendency towards large units, which is not surprising if one considers that for the calcium-carbide industry alone about half a million horse-power in generating plant has been installed throughout Europe, and that most of the power has to flow through transformers to the carbide furnaces.

The General Electric Company of America have built several 10,000-kw. three-phase transformers working at 60 frequency, and giving a pressure of 100,000 volts. The largest European transformers of which I could find a record are some made by the Siemens-Schuckert Werke. They are three-phase 6750-kilovolt-ampere capacity oil cooled, for 66,000 volts on the high-pressure side. The use of oil as a filling medium has made it possible to build transformers for very high pressure. In one American power-transmission plant now under construction the step-up transformers are intended to raise the pressure to 110,000 volts, but even higher pressures can be obtained. Transformers giving extremely high pressure on the secondary are used for testing insulators and insulating material. A transformer of this kind has recently been made by Messrs. Brown-Boveri. It is a 50-kilovolt-ampere transformer wound for a primary pressure of 1000 volts and giving on the secondary 250,000 volts, but even this has been exceeded when the transformer was used in testing the dielectric strength of insulators. From a curve referring to such tests which the makers have sent me I find that the highest pressure recorded was 310,000 volts.

The reduction in weight of transformers due to the use of alloyed iron, large units, and vigorous cooling is very remarkable. As an example of good modern practice, I take a Brown-Boveri transformer where the active material weighs only 3·1 kg. per kilowatt, and the efficiency is 98·6 per cent. at full non-inductive load. In an Oerlikon 3500-kw. transformer the active iron only weighs 7 tons, being at the rate of 2 kg. per kilowatt output. The largest self-cooling oil transformers of which I know are some 1200-kw. three-phase 40-frequency 5000-volt transformers made by the British Westinghouse Company, but for larger unit artificial cooling becomes necessary.

For furnace work it is well to allow a rather large inductive drop so as to reduce the rush of current in the event of a short circuit in the furnace. This means wide spaces between primary and secondary coils, but it also involves the necessity for good mechanical support. The mechanical forces acting on the individual coils may become considerable, and this is probably the reason why some makers prefer the core type with concentric cylindrical coils, the cylinder being the best shape for resisting radial forces.

[1] Abridged from an address delivered before the Institution of Electrical Engineers on November 11 by Prof. Gisbert Kapp, president of the institution.