stratums of these metals that light passed through them in sufficient quantity for observation. The rotation produced by the glass and the exceedingly thin film of platinum was determined once for all and allowed for. Kundt obtained the remarkable result that the magnetic rotatory power in iron is so great that light transmitted through a thickness of one centimetre of iron magnetised to saturation is turned through an angle of over 200,000°, that is, that light passing through a thickness of an inch of iron magnetised to saturation would have its plane of polarisation turned completely round more than a thousand times; in other words, one complete turn would be given by a film less than $\frac{1}{1000}$ of an inch in thickness. A scarcely smaller result has been found by Du Bois for cobalt, and a maximum rotation of rather less than half as much by the same experimenter for nickel.

The direction of turning in all the cases which have so far been specified—that is, Faraday's glass, bisulphide of carbon, iron, nickel and cobalt—is the same as that in which a current of electricity would have to flow round the spires of a coil of wire surrounding the specimen so as to produce the magnetic field. This we call the *positive* direction. There are, however, many substances in which the turning produced by the magnetic field is in the contrary or negative direction; for example, ferrous and ferric salts of iron, chromate and bichromate of potassium, and in fact most compound substances which are feebly magnetic.

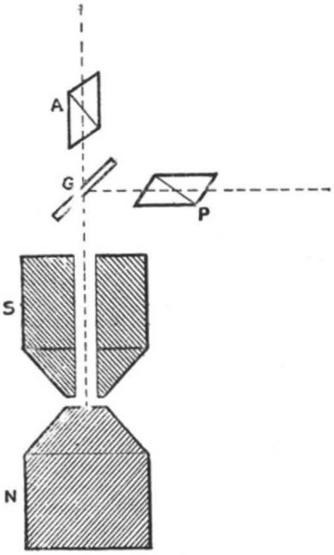

FIG. 6.

Faraday established by his experiments the fact that substances fall into two distinct classes as tested by their behaviour under the influence of magnetic force. For example, an elongated specimen of iron, nickel or cobalt, if freely suspended horizontally between the poles of our electro-magnet, would set itself with its length along the lines of force. On the other hand, a similar specimen of heavy glass, or a tube filled with bisulphide of carbon, would, if similarly suspended, set itself across the lines of force. The former substances were therefore called by Faraday paramagnetic, the latter diamagnetic.

It might be supposed that diamagnetics would show a turning effect opposed to that found in paramagnetics, but this is not the case. As we have seen, bisulphide of carbon and heavy glass, which are diamagnetics, show a turning in the same direction as that produced in iron—as indeed do most solid, fluid and gaseous diamagnetics. Feebly paramagnetic compound substances, on the other hand, produce negative rotation.

A theory of diamagnetism has been put forward in which the phenomena are explained by supposing that all substances are paramagnetic in reality, but that so-called diamagnetic bodies are less so than the air in which they are immersed when experimented on. Thus the diamagnetic quality is one of the substance relatively to air, in the same kind of way as the apparent levity of a balloon is due to the fact that its total weight has a positive value, but is less than that of the air displaced by the balloon and appendages. Lord Kelvin's dynamical explanation of magneto-optic rotation does not bear out this view of the matter.

Before passing to the dynamical explanation, however, I must very shortly call attention to some remarkable discoveries in this subject made by Dr. John Kerr, of Glasgow. I have here an electro-magnet arranged as in the diagram before you (Fig. 6). The light from the lamp is first plane polarised by the Nicol P, then it is thrown on the piece of silvered glass G, and part of it is thereby reflected through this perforated pole-piece so as to fall normally on the polished point of the other pole-piece. Reflection thus takes place at perpendicular incidence, and the reflected light is received by this second Nicol. When the magnet is unexcited the second Nicol is arranged so as to quench the reflected light. The magnet is then excited, and it is found that the light is faintly restored, showing that an effect on the polarisation of the light has been produced by the magnetisation. It is to be noticed here that the incident and reflected light is in the direction of magnetisation. We shall not pause to make this experiment. It was arranged this morning and successfully carried out; but the effect is slight, and might not be noticeable without precautions, which we have hardly time to make, to exclude all extraneous light from the screen.

It would perhaps be incorrect to say that the plane of polarisation has been rotated in this case, as it has been asserted by Righi that the light after reflection is no longer plane polarised, but that there are two components of vibration at right angles to one another, so related that the resultant vibration is not rectilinear but elliptical. There is therefore no position in which the analysing prism can be placed so as to extinguish the reflected light. The transverse component necessary to give the elliptic vibration is, however, in this case, if it exists, very small, and very nearly complete extinction of the beam can be obtained by turning the analysing prism round so as to stop the other component vibration. The angle through which the prism must be turned to effect this is the amount of the apparent rotation. The direction of rotation is reversed by reversing the magnetism of the reflecting pole. Dr. Kerr found that the direction is always that in which the current flows in the coils producing the magnetisation of the pole.

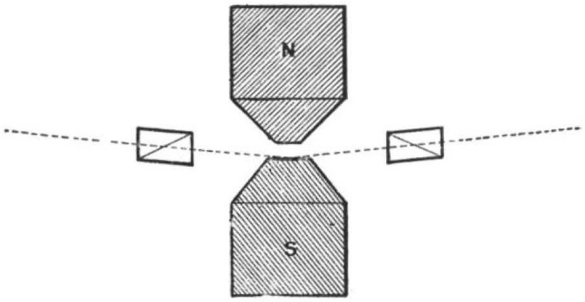

FIG. 7.

Dr. Kerr also made experiments with light obliquely incident on a pole-face, with the arrangement of apparatus shown in this other diagram (Fig. 7). He found that the previously plane polarised light was by the reflection rendered slightly elliptically polarised. A slight turning of the analysing Nicol was necessary to place it so as to stop the vibration corresponding to the long axis of the ellipse and so secure imperfect extinction.

These effects are, like those of normal incidence, very small, and they can hardly be shown to an audience.

(*To be continued.*)

SCIENCE SCHOOLS AND CLASSES.[1]

THE annual Report of the Department of Science and Art furnishes much information on the progress made in elementary scientific instruction year by year; and the following facts, derived from the Report just published, shows the vast extent of the Department's operations during 1898. The number of students under instruction in schools eligible for the

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[1] Forty-sixth Report of the Department of Science and Art of the Committee of Council on Education, with appendices. Pp. 320. (H.M. Stationery Office, 1899.)

Department's grants in that year was 158,370. These students were distributed among 11,723 classes in 2023 different schools. Scotch schools and students are not included in these figures, the Scotch Education Department having taken over the administration of grants for science and art instruction. Even more satisfactory than the increase of the number of pupils receiving science instruction is the fact that in 1898 there were 159 Schools of Science—that is, schools following an organised course of scientific instruction—in which practical work forms an essential part. The number of students in these schools was 21,193. This is a considerable increase on the preceding year, when the number of Schools of Science was 143, with 18,142 students.

For the year 1898 the grants to science schools in England, Wales and Ireland, exclusive of those made to training colleges, amounted to 169,604*l.* 3*s.* 3*d.* The sum included (*a*) 85,862*l.* to science schools for attendance grants, and 614*l.* on results of examination (honours only); total, 86,476*l.*; (*b*) 82,998*l.* to Schools of Science, for capitation and attendance grants and grants on results of examination.

The figures under (*a*) show an average payment in 1898 of 12*s.* 7½*d.* for each individual student under instruction in science schools, whilst the average payment per student under instruction in Schools of Science (*b*) was 3*l.* 18*s.* 2*d.*

The grants now made to schools are based upon the attendance of pupils, instead of being computed on the results of the individual examinations. Referring to this change and to the increase of practical work, Captain Abney, the Director for Science, says:—"In the past year, the system of payments by attendance was made general to all schools except in the case of Schools of Science. From this mode of payment candidates for honours were necessarily omitted, their work being necessarily special and requiring special treatment. The abolition of payments on results has diminished to some extent the numbers of students who were presented for examination, and the course of instruction in the various stages of the subjects of science for which payments are made will be more prolonged. This undoubtedly tends to sound instruction. . . . There is a decided increase in practical instruction in various subjects, and in many places laboratories for physics and for biological subjects have been provided, as the higher attendance grant is only attainable where such provision has been made. I cannot help commenting upon the very marked impression that the obligation to give practical instruction in science has made in the elaboration of apparatus for teaching purposes. At a conference on science teaching, held at the Chelsea Polytechnic under the auspices of the London Technical Education Board, there was an exhibition and demonstration of the use of science apparatus in teaching. The novelties in apparatus and the general interest taken in the conference by science teachers and others clearly indicated the rapid advances that had been made in this branch of teaching"

The Reports of the Inspectors of the Department include many points worthy of the consideration of educationists. The following extracts contain a few of the views expressed on the general subjects of secondary schools and science teaching; and as they represent opinions based upon direct experience of the conditions of elementary scientific instruction in this country, they have exceptional value.

Extracts from Reports.

Many of the smaller secondary schools are still badly equipped for teaching purposes. Most of them are ill-supplied with funds, and have consequently an inadequate and inferior staff of teachers, while some few are bent upon continuing methods and subjects of instruction which must be of little value to the class from which their pupils should be drawn. It is, moreover, impossible to deny that owing to the practical absence of outside criticism some few secondary schools are hopelessly inefficient. . . . Many country grammar schools have reason to be thankful to the County Councils for the very liberal aid they have received towards the erection or equipment of suitable rooms for science purposes, or towards the payment of a science master. The County Councils can for their part in most cases ensure that the science work is thoroughly and systematically given by requiring the school to place itself in connection with the Department. To this the best and most progressive of the smaller schools offer no objection. They realise that assistance from public funds must be accompanied by some amount of public control, and as a rule the visit of the inspector is most feared where it is most unknown. Still, in spite of County Council assistance and Department grants, many of the endowed grammar schools are still in straitened circumstances. Where fees are low and endowments small, it is often a serious matter to secure a proper staff of teachers, to keep fittings and apparatus in a proper state of completeness, and to provide for the necessary outlay on repairs, rates and taxes. It is therefore not a matter for surprise if the science and art appliances in some of the secondary schools are found to be meagre in quantity and poor in quality.

On the whole, it may be said that a very fair provision has been made for scientific and technical instruction of the youth of the country up to, at any rate, the age of sixteen or seventeen, supposing them to devote themselves to study until attaining that age, and that in most large towns the artisan and manufacturer can obtain good instruction in technology and general science. But our larger polytechnics could be much further utilised if research work in their laboratories were more encouraged.

It would be most helpful to the technical education of the country if a fairly liberal grant could be paid on any student who, having acquired sufficient training in science, devoted himself to some special work in a laboratory under the supervision of the teacher in charge. The results of such work might be examined and criticised by the professors and examiners of the Department, and, if worthy, brought to the notice of the various societies for the promotion of scientific investigation.

The freedom from examination in the elementary courses of Schools of Science has had considerable influence on the character of the teaching, especially in the practical work. Teachers have awakened to the fact that science may afford a sound mental training, and that method is no less important to a student than results. Syllabuses exhibit a more logical sequence. Instead of depending upon a course thought out by others, teachers are beginning to think out their own, and although there is room for improvement, enlightened methods are making way. The "Heuristic method," which seeks to make each boy or girl a "discoverer" of known physical laws, and thus develop in him the scientific spirit, has had an important influence on the teaching of science. In the hands of a highly competent teacher it is an important guiding principle—in the hands of some of its disciples there is danger of its becoming a fetish. The Heuristic method is essentially historical; the pupil is told little, but is put in the way of finding out for himself, which is well. But there is as much danger in telling him too little as in telling him too much. It is not perhaps impertinent to point out that scientific discoveries have seldom been inductive. Investigators have been acquainted with the results of other discoverers, and have had, almost invariably, a "working hypothesis" which they have sought to establish by deductive methods. It is therefore advisable to lay stress on the usefulness in teaching science of a "working hypothesis," which should form the basis of practical work having for its object the "discovery" of a law. Though the beginner "must be put in the position of an original discoverer," it should be borne in mind that an original discoverer has at his disposal the observations and views of other investigators. It is only fair that the student should be placed in pretty much the same position, otherwise his observations will be ill-directed, and will lead him nowhere. It is almost needless to remark that in any case the advanced work may be more didactic.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE natural history collections in the Whitechapel Public Library and Museum are being systematically used by many teachers in the elementary schools of the district to illustrate object lessons. Teachers who propose to utilise the collections for this purpose send to the curator, Miss Kate M. Hall, a list of the object lessons they are giving, and arrangements are then made for one or more practical demonstrations bearing upon the lessons. The children (about forty-five in number) are brought up to the museum every week, for 1 to 1½ hours, until the course is finished. They are divided into three groups of fifteen, and each group spends about twenty minutes at each table on which the specimens chosen for the lesson have been placed. In this way the children have the opportunity of closely observing the objects, and of comparing the structure