been taught "how to learn," that they are deficient in resource, in self-help, in curiosity of the right kind. In the majority of cases they are quite incapable of thinking for themselves, and in a large number of cases they cannot express their ideas, if they have any, in simple English. Such consequences necessarily follow from the old bad system of "payment by results" in the elementary schools, and from obsolete and defective methods of teaching, coupled with the worship of examinations, in the secondary schools.

The type of school proposed for filling the "gap," under whatever name it may be known, is one which aims at taking the best children of the elementary schools sufficiently early in their career to enable them to reach a somewhat higher standard of attainment than is aimed at in the elementary schools themselves. For good reasons, which are set forth in the report, the age at which the change from the elementary school should be made is considered by the committee to be not less than twelve years. At this age the best pupils of the schools, selected by some simple qualifying examination combined with reports from the head teachers, are to be drafted into the new type of school. In this school the length of the course is to be three years, so that the pupils should remain there until they are fifteen years old. To ensure this, it is felt that the parents of all pupils so transferred should be put under a moral obligation to maintain them at the school until the completion of the period, though it is recognised that it is not practicable to make the obligation a binding one in the legal sense.

The curriculum in the new type of school will differ within certain limits according to the needs of the locality in which it is placed, being different for (*a*) country districts, (*b*) the smaller towns of 20,000 to 50,000 inhabitants, and (*c*) large towns. Whilst specialised instruction such as is proper to the technical institute or the trade school is excluded, the aim of the school, in whichever of the above environments it may be placed, is to prepare the pupils more thoroughly for their life-work. Speaking generally, the curriculum is to consist (1) of what are usually classed as humanistic subjects; (2) of scientific and mathematical subjects; and (3) of manual instruction, with some physical training. In the humanistic section the English language and literature is to form the basis of the instruction, it being recognised that it is not possible to teach a foreign language effectively under the conditions, and Latin is of course excluded. History and geography are taken as subdivisions of the main subject. Class singing and religious instruction come under the same section, to which, on the whole, about one-third of the teaching time is to be devoted. In the scientific and mathematical subjects are included arithmetic, algebra, and the principles of geometry, all as applied to practical calculations; account keeping, as distinct from book keeping; graphical methods of calculation, mensuration, and elementary natural science, with experimental work done by the pupils and varied according to the environment. To this group of subjects another third of the time is to be given. The manual instruction includes, for boys, general wood and metal work, treated from an educative standpoint, and aiming at the training of hand, eye, and brain; in addition there is definite instruction in drawing of the non-professional kind, machine drawing, for instance, being excluded. For girls this manual instruction is replaced by training in domestic subjects and housecraft. Finally, about two hours per week are to be devoted regularly to physical training, which, of course, will differ, not only as between boys and girls, but also in different localities.

One great difficulty in carrying out this scheme is that of obtaining the right kind of teachers. It is insisted upon more than once that what is important is the method of teaching rather than the matter. The ideal teacher, it is pointed out, should be a man of character and ability, with freshness of mind, thoroughly alive to the environment, and thoroughly sympathetic with his pupils; he should be quite free from the old trammels which grew up in the dark ages referred to above, in which it will be remembered that the teacher who wished to rise to the higher posts in his profession was encouraged to pile certificate upon certificate in a great variety of subjects, in few, if any, of which, as results showed, was he really qualified to teach. Suggestions are made as to the training of these teachers, some of which appear to the writer not to be very practicable, more especially the suggestion that the teachers should spend one year in actual workshops. Apart from the difficulty of getting employers to be bothered with such men in their factories, the writer is of opinion that the year could be far more profitably employed in other directions, as the smattering obtained by so short an experience and so limited a view of commercial life is apt to be more harmful than useful. It is important to notice that the report emphatically recognises that for special technical subjects special teachers are required; but then these subjects are ruled out of the curriculum of the schools under consideration, and, indeed, such subjects as shorthand, machine drawing, book-keeping, industrial chemistry, and typewriting, some of which even modern schoolmasters are often inclined to view with favour, are set aside as unsuitable in any scheme of general education, whether secondary or elementary.

Considerations of space will not allow us to dwell upon many other important matters of detail which are handled in a masterly manner in this valuable report; suffice it to say in conclusion that it will well repay careful study, and certainly ought to be perused by everyone who is interested in the rapid developments which are taking place in the educational world.

R. M. W.

ELECTRIC TRAMWAYS.

THE leading feature of the current issue (No. 180, vol. xxxvii.) of the Journal of the Institution of Electrical Engineers is the paper on the overhead equipment of tramways by Messrs. R. N. Tweedy and H. Dudgeon, especially in view of the fact that the overhead system has been so abused of late years by the general public, and thousands of pounds sunk in other schemes of electric tramways which might have been enormously reduced if the prejudice which exists against the overhead system on account of its supposed "danger" had been removed. The authors throughout the paper make a strong appeal for more economy in the capital outlay of tramway equipment, and show how in their opinion this may be brought about in the case of the overhead system.

Dealing with the size of pole to be employed, the authors are strongly of the opinion that we err seriously on the side of using too heavy and too strong poles, straining them too much, and consequently having larger span wire and more concrete for fixing than is necessary. Also they would do away with the usual cast-iron bases which protect the poles, as being not only a waste of money—being unnecessary—but also an actual source of danger, in that they prevent the pole within them from being painted when the outer portions are done—unless the box is lifted, a costly process—and allow water to accumulate inside the case which causes the pole to rust badly.

The same remarks apply to the collars which it is customary to place round the joints in the poles, and water is liable to do much damage here also. If the bases are not done away with they must be ventilated and drained, so as to prevent the accumulation of water from sweating. The collars also must be drained properly. More economy is to be brought about in the trolley-wire itself, as in the authors' opinion too large a section is now being used, and they think that from 56*l.* to 80*l.* per mile may be saved on this charge alone. Again, referring to the "hangers," the authors strike out strongly for the use of malleable iron in place of bronze and gun-metal fittings, which are so dear to some engineers—and are also dear in price as compared with malleable iron properly galvanised.

No local action takes place—with the malleable iron hanger—between the span wire and hanger as is the case with bronze hangers, and from experience iron hangers have been found to last longer than bronze or brass ones, though the oxidation of the iron bolts is one of the difficulties attendant on the overhead system. The authors suggest three methods of overcoming the difficulty:—

(*a*) The insertion of a shield between trolley-wire ear and the hanger to prevent the trolley wheels throwing water up into the interior of the hanger—thus keeping the bolt dry—and "neither rust nor electrolysis can corrupt."

(*b*) A different form of hanger—simply a metallic link between the ear and span wire, and insulated by two or three independent external insulators.

(*c*) The hanger to be composed of glazed porcelain with a plain metal bolt passing through, but the porcelain must be kept dry and sheltered from rain.

Several other points of interest are touched upon by the authors, and the discussion which followed the reading of the paper by Mr. Tweedy proved that the opinions on the points raised by the paper were very varied, and led to a keen criticism. The idea of a shield was generally welcomed, and a suggestion was made that it should be manufactured in such a form as to be readily adjusted to existing hangers, without having to dismantle the same.

On the subject of the strength of poles, however, the majority was against any reduction in size, and the question of the Standard Committee's "standard pole" provoked an animated discussion.

The subject of the paper is one which for a long time has needed discussion, and the interest in it was shown by the fact that, after the paper was read and discussed at the Birmingham local section's meeting, it was rediscussed in London later in the session, and we may hope that the many points and facts brought forward will help to mitigate the present existing difficulties of the overhead system, and at the same time help to reduce the capital expenditure on tramway schemes that may be undertaken by local authorities.

SOME ASTRONOMICAL CONSEQUENCES OF THE PRESSURE OF LIGHT.[1]

JUST a year ago Prof. Nichols gave here an account of the beautiful experiment carried out by himself and Prof. Hull which, with the similar experiment of Lebedew, proved conclusively that a beam of light presses against any surface upon which it falls. Not only did Nichols and Hull detect the pressure, which is difficult enough, so minute is it, but they measured it with extraordinary accuracy, and confirmed fully Maxwell's calculation that the pressure on 1 sq. cm. is equal to the energy in 1 cubic centimetre of the beam.

Thus we have a new force to be reckoned with. It is apparently of negligible account in terrestrial affairs, partly in that it never has free and uninterrupted play. But out in the solar system, where there is no disturbing atmosphere, and where it may act without interruption for ages, it may produce very considerable results. Even here, so minute is the force that it need only be taken into account with minute bodies. Prof. Nichols in his discourse told how it may possibly account for the formation of comets' tails if these tails are outbursts of finest dust. To-night I shall try to show how it may be of importance with bodies which, though still minute, are yet far larger than the particles dealt with by Prof. Nichols. Such small bodies appear to abound in our system, and to reveal their existence on any starlight night when perishing as shooting stars.

We are to examine, then, how the pressure of light, or more generally the pressure of radiation, from one end of the infra-red to the other end of the ultra-violet spectrum will affect the motion of these small bodies.

I think we get a clearer idea of the effects of light or radiation pressure if we realise from the beginning that a beam of light is a carrier of momentum, that it bears with it a forward push ready to be imparted to any surface which it meets.

Thus, let a source A (Fig. 1) send out a beam to a surface B, and to bring out this idea of carriage of momentum let A only send out light for a short time, so that the beam does not fill the whole space from A to B, but only the length CD. While the beam is between A and B, B feels nothing. But as soon as D reaches B, B begins to be pushed, or it receives momentum in the direction AB, and will continue to feel the push or receive momentum until C has reached B, when the push will cease. The existence of this push on B is definitely proved by the experiments of Lebedew and Nichols and Hull. Now, unless we are prepared to abandon the conservation of momentum, this momentum must have existed in the beam CD and have been carried with it, and it must have been put into the beam by A while it was sending forth the waves. A, then, was pouring out forward momentum, and was feeling a back push while it was radiating. This back push against the source has not, I think, been proved to exist by direct experiment, though an indirect proof may perhaps be afforded by the case of reflection. When a beam is totally reflected, the push measured in light-pressure experiments is double that when it is absorbed, that is, there is a push by the incident beam and an equal push by the reflected beam, and we may perhaps regard the reflected beam as starting from the reflector as source, and then we have a push back against the source. But whether this be proof or not, I do not see how there can be the slightest doubt that the pressure against the source exists, and that for the same intensity of beam it is equal to that against a receiving surface.

FIG. 1.

Some experiments which have been made by Dr. Barlow and myself appear to bring to the front this conception of light as a momentum carrier. When a beam falls on a black surface it is absorbed—extinguished—and its momentum is given up to the surface. In a beam of light AB (Fig. 2) the momentum is a push forward in the direction AB, and if it falls on a black surface S it gives up this momentum to S. The total push which is in the direction AB may be resolved into a normal push N and a tangential push T. If S can move freely in its own plane, and only in that plane, T alone comes into play, and S will slide towards *s*.

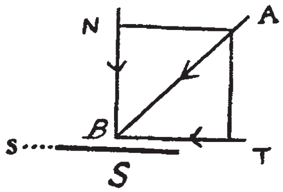

FIG. 2.

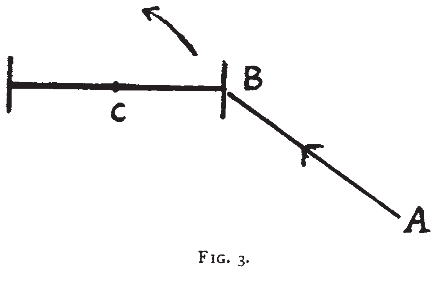

FIG. 3.

To show this effect we fixed two glass discs at the end of a short torsion rod hung by a fine quartz fibre the discs being perpendicular to the rod, and the face of one of them being blackened. Fig. 3 shows a plan of the arrangement. The apparatus was enclosed in a glazed case, which was exhausted to about 2 cm. pressure of mercury. On directing a horizontal beam AB at 45° on to the black surface B, the normal force merely pressed B back, but the tangential force turned B round the point of suspension C away from AB. It is difficult to make the disc quite symmetrical and the beam quite uniform, and

---

[1] Discourse delivered at the Royal Institution on May 11, by Prof. J. H. Poynting, F.R.S.