Research in Industry.

IN a lecture on "Research in Industry and Rationalisation", delivered before the Society of Swedish Engineers in Great Britain on May 27, Mr. Axel Y. Enström discussed the way in which research and rationalisation have become indispensable factors for the economic development of industry. Science and research have now come to be marshalled among the working tools of industry in daily use, and the post-War period can supply many examples of the fruitful association of scientific and industrial research. Mr. Enström considers that Sweden's ability to attain a position in the world's markets has largely depended on the purposeful incorporation of scientific research, well-equipped laboratories, and a highly qualified staff with her industrial activity. There are now in Sweden about fifty works' research laboratories, which employ some six hundred persons and represent all the large industrial undertakings. The total cost of the industrial research carried on in Sweden is probably about four to five million crowns.

Discussing the special characteristics of scientific and technical research, Mr. Enström suggested that spontaneous research, such as Röntgen's discovery of the Röntgen rays, is typical of the former, and the systematic research which Hertz based on Maxwell's equations is typical of the latter. Even in systematic research, however, fundamental or scientific research, as well as a high standard of scientific technique, may be essential. Disregard of fundamental scientific principles may lead to enormous waste in technical research, especially in experimental plant work. After such technical investigations on a metallurgical process in Sweden, involving an outlay of several millions, had been abandoned as fruitless, scientific investigations on the interaction of ore particles and gases yielded a solution. The importance in technical research of a thorough knowledge of the fundamental physical and chemical sciences cannot be overstressed, but such a combination is difficult to find.

Other factors in technical research which may eliminate much wastage of time and labour are mathematical analysis of the possibilities at an early stage in the investigations, and the thorough study of the information already existing either in the literature or in technical sources before experimental work is undertaken. Related to these factors is the standard of experimental technique of the investigator and his knowledge of the possibilities and limitations of that technique. Similar qualities are increasingly involved in technical analysis and process control, and the essential factor in all the scientific control and development of industry may thus be briefly described as clear thinking.

In this description it is easy to include rationalisation, which, like technical research, aims at improving, increasing, or cheapening production. While suggesting that discussion as to whether the continued displacement of labour by machinery is justifiable is premature, Mr. Enström considered that rationalisation must progress with natural necessity. We have no general view of the correct proportion between direct production for consumption and production of machinery or tools. Economic history suggests that equilibrium is continually re established on a fresh basis when the proportion is disturbed. Standardisation is an important element in rationalisation, and the research work on manufacturing processes not only leads to standardisation of processes and improved efficiency but also may frequently have a far-reaching rationalising effect. The application of scientific principles and methods of investigation to industrial problems inevitably leads sooner or later to the application of the same principles and methods to the conduct of the whole industry. Technical research and scientific management are thus two important aspects of rationalisation, and the future of industry largely depends on our ability to produce industrial leaders competent to evaluate these factors, with the economic, social, and other factors involved.

The Flying Fox in Australia.

TWO years ago, Mr. F. N. Ratcliffe was appointed by the Commonwealth Council for Scientific and Industrial Research to obtain for it as complete a picture as possible of the flying fox (*Pteropus* spp.) population of Queensland and New South Wales, its significance and extent, the relations of the different species one to another, the nature and cause of their migrations, the individual and collective habits of the animals, and the extent and value of the economic losses involved. Fruit-growers had at times complained loudly of orchard depredation by this pest and demanded governmental action to exterminate it. The Council was somewhat sceptical about the alleged facts: hence this inquiry, which received financial support from the Commonwealth, New South Wales, and Queensland Governments. Mr. Ratcliffe has now completed his work, and furnished to the Council a report which is not only most interesting reading but also is admirably fearless in its criticism of current ideas and practices.

Four species of flying fox are found in Australia: *poliocephalus*, *Gouldi*, *conspicillatus*, and *scapulatus*. They are practically confined to coastal areas, and their numbers, which cannot be accurately assessed, must amount to many millions in the numerous 'camps' scattered along a north–south stretch of some two thousand miles. There has, no doubt, been a diminution in numbers as settlement has progressed in New South Wales and South Queensland, the present population amounting probably to only about half that of early days. As in the past, so to-day, the principal food of all species is undoubtedly blossom, chiefly of eucalypts, and Mr. Ratcliffe has been forced to the conclusion that the current opinion that the fox is guilty of appalling destruction in fruit plantations is a gross exaggeration, so far at least as the commercial fruit crop of Queensland is concerned. Attacks on orchards are more an indication of general food shortage than evidence that cultivated fruit is an essential part of the animal's food supply. Such fruits as bananas, pineapples, citrus, pawpaws, and apples are, as a matter of fact, too hard for the weak dentition of the little red fox (*P. scapulatus*), which is equal in numbers to all the other species put together. *P. poliocephalus*, however, finds no difficulty in attacking these, when ripe: though here again it is important to remember that normally all these fruits, except perhaps citrus, should be picked for market while still unripe and therefore unattractive to the foxes. In other words, if the growers harvest these particular crops in satisfactory fashion, the loss to the commercial fruit industry in Queensland resulting from flying fox infestation should be almost trifling.

One must not forget, however, that what may be called ' back garden ' fruit is usually left on the trees until almost, or quite, ripe, and therefore is far more attractive to, and more readily attacked by, the bats than the greener product. This probably accounts for far more general popular outcry against the animals than the actual economics of the situation justify. Still, looking at the matter merely from a business point of view, if the fox is not a menace to the large-scale commercial industry, there would seem to be little valid reason for any considerable expenditure of public money on its control.

Nevertheless, big losses occasionally occur, notably where soft fruits (figs, peaches, nectarines, etc.) are grown. The problem presented by these is much greater in New South Wales than in Queensland. Hence Mr. Ratcliffe has felt it necessary to discuss critically various methods which have been proposed for coping with the trouble. Control through direct destruction by shooting, he rules out as a physical and economic impossibility. Attack by contagious or infectious disease is probably hopeless. There is now such a mass of experience indicating the improbability that control can ever be brought about in this way that it seems not worth while even to initiate experiments. The use of poison gases in the camps is almost impracticable and, on good evidence, ineffective. Flame guns are useful to an extent, but objectionable in many respects, including that of the cruelty involved. As for the ' scalp bounty ' system, as adopted by Queensland, Mr. Ratcliffe's condemnation of it is as emphatic as it is just. He shows that in one important area, if every penny of the money provided by the Pests Destruction Board as bounty were spent solely on foxes, at 3*d*. per animal, the total destruction would probably be less than 1 in 200 of the normal population. Even then, *P. scapulatus*, because the least intelligent species, would usually be the most heavily hit: as it is also the least troublesome, money spent on it would be sheer waste.

Apart, however, from attempts at mass control, much protection might be afforded in small localised areas by systematic use of deterrents and poisons by the fruit-growers, and recommendations are made for the encouragement of such practices.

It seems, then, that the economic significance of the bat trouble in Australia is not really very great; it has certainly been exaggerated. The fox is a nuisance rather than a pest, affecting chiefly the small home grower and not the commercial fruit industry. Possibly, as Mr. Ratcliffe suggests, the reason for the prevalent exaggeration is partly psychological. The bat is nocturnal, noisy and smelly, and usually infested with parasites; in fact, decidedly detestable. It is no wonder, perhaps, that Mr. Ratcliffe found astonishing numbers of individuals prefacing their information regarding the foxes with a statement that they were "stinking, lousy brutes". Such an attitude is not without significance when one is seeking an unbiased assessment of the economic importance of a nuisance.

Be that as it may, the upshot of this very interesting inquiry should be to convince Australia that one, at least, of her pests is not so bad as it has been represented, and is not likely to become any worse. This will be some comfort to the Council for Scientific and Industrial Research, which finds decreasing funds and increasing responsibilities to be matters of grave embarrassment at the present time. A. C. D. R.

Young's Theory of Colour Vision.*

ALTHOUGH Thomas Young is well known as the founder of a theory of colour vision, his contributions to the theory are limited to two or three short paragraphs, and there is no evidence that he himself attached much importance to them. He was the first who, starting from the well-known fact that there are three primary colours, sought for the explanation of this fact, not in the nature of light, but in the constitution of man. He wrote: "Now, as it is almost impossible to conceive each sensitive point of the retina to contain an infinite number of particles each capable of vibrating in perfect unison with every possible undulation, it becomes necessary to suppose the number limited, for instance, to the three primary colours—red, yellow, and blue . . . and each sensitive filament of the nerve may consist of three portions, one for each principal colour." He afterwards took red, green, and violet as the three primary colours. His other statement regarding colour is in connexion with Dalton's colour-blindness, of which he says: "It is much more simple to suppose the absence or paralysis of those fibres of the retina which are calculated to perceive red".

Although the three component theory as developed by Clerk Maxwell, Helmholtz, and others accounted well for many of the facts of colour mixture, it had also to account for other phenomena of vision, such as visual acuity, the luminosity curve, hue discrimination, simultaneous and successive contrasts, and colour-blindness. Recent work by Hecht and others has succeeded in solving many of these problems.

The determination of the luminosity curve, which physicists still persist in calling the ' visibility ' curve, has been the subject of such accurate investigation that it can now be regarded as one of the soundest scientific data in the whole realm of vision.

Dalton may be regarded as initiating the scientific study of colour vision, and later work by Seeback and Clerk Maxwell strongly supports the view expressed by Young that cases of colour-blindness are reduced forms of normal vision. On this theory, the neutral points of the spectrum as seen by protanopes and deuteranopes are excellently explained by the points of decussation of their two remaining curves.

The fact that yellow is psychologically as distinctive a colour as red, green, or violet, and physiologically shows no evidence of composite character, was long regarded as a strong argument against the trichromatic theory, until Hecht proved conclusively that the sensation of yellow could be experienced by fusing binocularly the sensations produced by appropriate red stimulation to one eye and green stimulation to the other.

Research since Young's day has done nothing to bridge the gap between the physiological and the psychological response, but considerable progress has been effected by Holmgren, Kohlrausch, Lucas, and Adrian in elucidating the physiological response itself. The results of these workers on the photochemical reaction of the visual purple, and the accompanying changes in electrical potential of the retinal structures, all tend to show that the fundamental phenomena of vision all manifest themselves in the retina.

Finally, the researches of Pieron, especially those on colour responses to black and white stimuli, and those of Allen on induction effects as shown on the persistency curves resulting from previous stimulation of the retina by monochromatic light, all have a distinct confirmation bearing on Young's theory.

* Substance of a paper read by Sir John H. Parsons, F.R.S., before the Optical Society on June 11.