plosion of cordite in a gun from the chemical constituents of the cordite. This possibility has gone far to raise internal ballistics from an empirical science to a branch of natural philosophy.

The advances which have taken place in the commercial development of chemical processes based upon this important new science of thermochemistry, although already considerable, are only in their infancy, but the men with the experience gained in practical development are very few; and as the experiments are generally very lengthy and expensive, the development of the industry is necessarily slow. The resultant saving to the country, however, will far outweigh the cost.

(To be continued.)

Indian Agricultural Practice and Research.

DURING the past century of British rule, many attempts have been made to improve Indian agriculture; but wave after wave of effort has broken, with little result, on the firm foundations of the indigenous practice of the country. Until within quite recent years, only in the fundamental matters of irrigation and reduction of famine has any notable advance been made. It is well, then, to look back and try to form a picture of the nature and origin of this indigenous agricultural practice.

When we do so, we are at once struck by the commanding position of the industry in former times, and the enthusiasm with which it was carried on. It is generally agreed that the Aryans, an agricultural people, entered the north-western part of India some 4000 years ago; and the view is also held, although more conjecturally, that the Dravidians, also noted agriculturists, had then already intrenched themselves in the south. Of the latter we have little knowledge. But there is detailed evidence in the ancient writings of the delight with which the Aryans regarded cultivation—witness the following extracts from a pastoral hymn on ploughing in the Rig Veda (period 2000 to 1400 B.C.): "Let the god of rains moisten the earth with sweet rains . . . may the crops be sweet to us . . . turn the sod merrily, let the oxen work merrily, let the plough move on merrily, fasten the yoke merrily, apply the goad merrily."[1] Allowing for a certain poetic exaltation, this was a bright beginning; and was undoubtedly followed by a great development of agricultural knowledge and practice in north India. There appears to have been steady progress at any rate until the early part of the Buddhist period (500 B.C. to A.D. 500); and western knowledge of Indian agriculture dates from this period, in that it was carefully studied by the Greeks, shortly after Alexander the Great entered the country in 326 B.C.

In ancient India, soils were classified according to colour, taste, productivity, and suitability to particular crops; alkalinity was known and feared; irrigation was widely spread, by dams, tanks, and wells; methods of dry farming were practised; deep ploughing was universal; manuring with animal residues and with oil cakes was practised, and green manuring was known and valued; paddy was sown in nurseries and transplanted into puddled fields; most of the crops now grown were cultivated; the seasons and rains were well understood and allowed for, and agricultural practice seems to have reached a high level.[2] But after the peak was reached, there would appear to have set in a steady decline both in the enthusiasm for agriculture and in the importance attached to it. Most of the details have, however, been handed down by example and oral tradition to the present day. But an Indian writer, after discussing these ancient glories and the progress being made elsewhere, allows himself to describe the Indian cultivator as "an ignorant, custom-bound creature, forced to content himself with his lot." Naturally, the inquiring western student will not altogether agree with this; rather is he struck by the wealth of detail, the rare economy, and the surprising adaptation to environment; and he soon discovers in that environment the main reason why Indian agricultural practice appears to be a mass of contradictions, when first viewed by those trained in western scientific methods.

Putting it briefly, the work of the Indian cultivator is often excellent, considering the limits of his conditions and resources. The first business of any one desiring to improve matters must be a study of this environment. The important benefit conferred by British rule in the development of irrigation has been already referred to; the next great advance was made when, in the early years of the present century, the Government at last recognised the necessity of founding an adequate agricultural department and allocating funds for its permanence. This was done on a generous scale by Lord Curzon, and during the past quarter of a century this department has been expanding and 'digging itself in'; in place of some half-dozen agricultural officers, nearly 200 superior posts have been created, and the number is daily increasing.

Defining research as the detailed study of any subject by a scientifically trained mind, the first difficulty of these officers was to bring their training into alignment with Indian conditions. Any attempt at betterment was of necessity dependent on a knowledge of the local climate, soils, stock, implements, crops, and the resources of the people. Amelioration or alteration was obviously needed, but a series of interlocking factors made this very difficult. Irrigation and dry farming had been practised from ancient times, but are always susceptible of improvement. There is plenty of good soil in India, but much of it has, by continual cropping without due return, reached the verge of 'permanent infertility.' There is a marked deficiency of pasture land, and what there is, is often very inferior; the cattle, therefore, although

[1] "Ancient India," R. C. Dutt, 1896.

[2] G. Jogi Raju, *Journal Madras Agricultural Students' Union*, **8**, 2-4, 1920.

numerous, are generally small and weak. As a consequence of this, agricultural implements have to be designed with an eye to the strength of the animals rather than the needs of the soil. Lack of humus and nitrogen content are characteristic of cultivated land in the tropics; and cattle manure is easily the most suitable material for remedying this. But most of this manure is, in India, of inferior quality and the bulk is used as fuel; while the rich nitrogenous residue from oil pressing is largely sent out of the country. Pure seed is practically unknown, a field of any crop being usually a mass of unselected varieties. Taking all these things together, the cultivator gets little out of the soil; it is not to be wondered at that he is poor, and anything like the accumulation of agricultural capital is out of the question. Without this capital it is difficult to see the way to any permanent improvement.

The principle of co-operation was early invoked, and some of the first agricultural successes were largely dependent on its application. Agricultural co-operation has been an enormous success, and has spread through all the provinces, and it was long ago taken out of the hands of agricultural officers, with a department of its own. For a century efforts have been made to improve the character of the crops grown, largely by introducing strains grown elsewhere; and one of the first lessons learnt in the new department was that this method was unlikely to succeed to any great extent, but that in the *mixtures* grown many forms were worth selecting and purifying. Work in this direction has been a great success in almost every crop studied, and some seven or eight million acres are now under selected strains of wheat, cotton, jute, and rice; while hybrid canes have been evolved which are rapidly replacing the former inferior kinds.

These two lines of work, co-operation and seed selection, are readily appreciated by the cultivators, and obviously place him in a better financial position. They may thus be regarded as laying the foundation for improvements in other directions. Meantime, a great deal of study was devoted to the pests and diseases of the crops grown, and means for their control worked out. Alterations in agricultural practice, because of its time-honoured nature, are much more difficult. It was soon seen that the importation of the costly and powerful implements of the West would be unsuitable in the circumstances; and as with the crops, a careful study was made of the local village equipment, costing a few shillings, on the chance of increasing its efficiency. Cheap models of improved ploughs, harrows, cultivators, etc., have been evolved; and some 30,000 of these are sold every year. But it must be confessed that a great deal more remains to be done.

There are some 150 million cattle in India, and this very number is one of the chief bars to their improvement in quality. Yet cattle may be said to represent the key factor influencing soil fertility and agricultural practice in India; and far too little research has been devoted to this difficult problem. An excellent Veterinary Department has existed for years, but it is only quite lately that a proper liaison has been effected between it and the Agricultural Department. One of the most encouraging features of the present-day research is the increasing attention being paid to cattle questions.

Agricultural research in India has, in the past, lagged considerably behind that in Great Britain, for the simple reason that the number of trained men employed was so absurdly inadequate for the work. The total area of the Indian Empire is given as some 1100 million acres. Of this, British India covers a little more than half, the rest being under native rulers; about two-thirds of British India is classed as cultivable. Such figures are impressive; but no one can appreciate the situation as regards research on the agriculture of the country, who has not spent the best years of his life in odd corners endeavouring to better things, continually making long train journeys over territory as yet untouched. This must be constantly borne in mind when reading of the successes of which the Agricultural Department is so justifiably proud. It is probable that not one hundredth part of the country has as yet been materially affected.

Taking the broad view, we may regard the efforts of the past quarter of a century as so much preparatory spade work; in almost every direction we know a great deal more about the crops and their environment, and can now form an opinion as to where progress may be reasonably expected. Encouraged by incidental successes along the path, the officers of the Agricultural Department are busy applying the most recent advances obtained elsewhere to the solution of their most pressing problems. It is only possible to refer here to one aspect of this development, namely, a fundamental study of the nutrition of man and beast under Indian conditions.[3] This study embraces the whole of agriculture, as well as veterinary science and certain aspects of medicine. In each case the soil is the basis; with cattle, its mineral constitution and the effect of this on the pasture and vegetable food generally; and with man, the inherent nutritional value of the staple foods of the different nations, and the effect of soil treatment on the nutritive value of the different cereals eaten. The two studies are interlocking. For example, it has been found that the nutritive value of cereals is distinctly higher when the crop has been treated with cattle manure than when artificial manures were used. It is obvious that a great many years of work will be needed before either of these projects can yield its full results. But a promising start has been made. Some of the analyses have shown a surprising difference in the proportions of the more important vitamins in the different cereals; and experimental feeding of animals has thrown suggestive light on the known variation in virility and disease resistance of the different nations inhabiting India—work which will awake interest far beyond the limits of the Indian Empire. C. A. B.

[3] "Royal Commission on Agriculture in India," vol. 1, part 2, 1927.