ROTHAMSTED RESEARCH

Report for 1962

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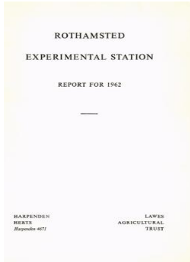
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EXPERIMENTAL STATION

REPORT FOR 1962

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General Report

Rothamsted Research

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GENERAL REPORT

F. C. BAWDEN

Regrettably the report must begin sadly by recording three deaths, two members of staff, A. Muir in February and J. R. Wilkinson in May, and a famous ex-member, Sir Ronald Fisher in July.

Muir came from the Macaulay Institute in 1945 to initiate and lead the Pedology Department. A year later, when the headquarters of the Soil Survey of England and Wales transferred to Rothamsted, he became head of the Survey, and since 1956 he was also a deputy director of the Station. This simple recital of the posts Muir held is alone ample objective evidence of his scientific eminence and ability, but it is far from indicating fully the loss that we and soil science have suffered. A world authority on soil classification and pedology, his services were repeatedly sought by countries or international organisations requiring advice about surveying, mapping or land use, and his extensive travels, including many in Russia where he was greatly respected, made his knowledge unique. This knowledge he was always willing to share, but greatly as we miss his technical advice, we equally miss his wise counsel in other affairs and his unfailing good humour, which made him such an excellent companion. That he should have died while the new laboratories he had planned for his department were being built made his death at 55 all the more untimely.

Wilkinson, who like Muir bore a distressing illness with remarkable cheerfulness and fortitude, was a valued member of the Chemistry Department and had contributed much to their programme of field experiments during the 16 years we were fortunate to have his service.

R. A. Fisher came to Rothamsted in 1919 as the first statistician and left in 1933 to become Galton Professor of Eugenics at University College, London. In these 14 years it is no overstatement to say that he revolutionised methods of experimentation, not only in agriculture but in all subjects that deal with variable material. The modern designs of experiments and methods of analysis for testing the significance of results, now generally adopted, and to which the recent great increases in agricultural production in many countries owe so much, all derive from his work. During these years, too, Fisher was developing his studies of genetics and evolution which became his main interests in London, and from 1943 to 1957 in Cambridge, where he was Arthur Balfour Professor of Genetics, and to which his contributions were as notable as those to statistics. During the war we had the good fortune to have Fisher back with us and derived much benefit from his scientific genius and pleasure from his charm and stimulating conversation. At the time of his death he was working in Adelaide with the Commonwealth Scientific and Industrial Research Organisation.

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Staff changes. To succeed A. Muir, G. W. Cooke was appointed deputy director, C. J. Bloomfield head of the Pedology Department, and D. A. Osmond head of the Soil Survey of England and Wales.

Four members retired after long and notable service: W. C. Game, who came in 1911; Mary D. Glynne, in 1918; H. V. Garner, in 1921; Signe G. Heintze, in 1930.

Awards. March brought an occasion for pride and pleasure when three members of staff, P. H. Gregory, A. Kleczkowski and H. L. Penman, had the distinction of being elected Fellows of the Royal Society of London. H. L. Penman's work was further acknowledged by the award of the O.B.E. in the Birthday Honours List and by a special "Merit" promotion to the grade of Deputy Chief Scientific Officer.

Sir John Russell. Sir John Russell celebrated his ninetieth birthday on 31 October, and in honour of the occasion Volume XXXVIII of the *Rothamsted Memoirs* was dedicated to him. A copy of the *Memoir* and other books were presented to him at a party given to him and Lady Russell on 26 October in the Manor House by the Staff Union. Sir John was his usual vigorous self and made a memorable speech, as remarkable for his stimulating ideas about the current and future needs of agricultural research as for the wit and humour he displayed in recalling its history.

Opening of Broom's Barn. The Minister of Agriculture, Fisheries and Food, the Rt. Hon. Christopher Soames, C.B.E., M.P., formally opened Broom's Barn Experimental Station on 27 July. He was introduced to the 200 guests, accommodated in reasonable comfort in the meeting hall, by the Earl of Radnor, Chairman of the Lawes Trust Committee, and thanked by Sir Peter Greenwell, Chairman of the Sugar Beet Research and Education Committee. The weather was agreeable enough for the display of fountains from the irrigation sprinklers to seem agriculturally reasonable, but with more than 2 in. of rain on the previous day, their function was purely aesthetic.

Buildings and land. The tarehouse and glasshouses at Broom's Barn, unfinished at the time of the formal opening, were completed soon afterwards, and the total facilities will now allow work on problems of sugar-beet growing to develop in ways previously impossible.

At Rothamsted the considerable extension to the West Building, which will house the Soil Survey and the Departments of Pedology and Biochemistry, was nearing completion at the end of the year. The site for a new range of glasshouses was also cleared and building started, but the weather in December halted this work.

After many long delays and frustrations, the rooms were completed in which plants can be grown in controlled environment. They allow one climatic factor to be changed while others remain constant and will first be used to gain information that will help to interpret the field work on the effects of weather on crop growth.

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At Woburn, where the number of experiments that could be done has long been restricted by the scarcity of land, we were fortunately able to rent an additional 44 acres, of which about half promises to be suitable for carrying experiments.

Visitors and visits. In addition to the people who visited Broom's Barn and Woburn, more than 3,000 came to Rothamsted. Visitors from overseas included His Highness the Maharajakumar of Sikkim, five members of the Japanese Parliament and Dr. Frank Welch, Assistant Secretary of the United States Department of Agriculture. We also welcomed many visiting workers, but although these were more numerous than usual, we regretfully had to refuse more applications than we could accept.

Nor could we accept all the invitations for members of the staff to visit other countries, though as the departmental reports show, several did travel overseas for various reasons. In addition to the visits listed elsewhere, F. C. Bawden was the guest of the International Society of Sugar Cane Technologists at their Congress in Mauritius in September and in December went to the Sudan to attend a meeting of the Agricultural Advisory Committee.

Liquidation of the Incorporated Society. When A. D. Hall was appointed director, in 1902, the buildings and facilities for research were woefully inadequate and, after he had failed to persuade the Board of Agriculture to finance the developments he considered necessary, the Incorporated Society for Extending the Rothamsted Experiments was founded in 1904 to raise the necessary money. This it did and has often proved valuable since, notably in making it possible to buy the Manor House and Estate in 1934 and to make extensive additions to the Station in 1939. However, it has not been active recently, and as current legal opinion is that its functions can all be filled by the Trust Committee, the Society went into voluntary liquidation.

The weather and crops. The cold spell at the end of 1961 left us wondering whether the sequence of years in which aphids have been abundant in spring would end. It did, but perhaps less because of the cold spell than because there never was any seasonable spring weather. From February on, every month until October was colder than average, with a spell at the end of May when the maximum temperature was only 46° F, 15° below average, and there were 8 nights with ground frost in June. In these conditions aphids were few and arrived in crops late, and the viruses they transmit caused less loss than for many years. Carrots perhaps illustrate the contrast most vividly; in 1961, when aphids were abundant, unsprayed crops became infected early with carrot motley dwarf virus and yielded only 6 tons/acre, whereas in 1962 they yielded over 24 tons. Yellows of sugar beet, too, was less prevalent in August than in any year since 1946. Aphid populations commonly reached on beet in May were not reached until July, and consequently few warnings were sent out of the need to spray. The acreage sprayed was much less than in 1961, but nevertheless was more than was justified; although not warned of the

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need to do so, some growers sprayed, and most of these wasted their money.

Aphids multiplied considerably late in the summer and spread yellows into the steckling beds of sugar beet and mangolds, where the disease was more prevalent in the autumn than for some years. However, in spite of this, the beet and mangold seed crops are unlikely to be dangerous sources of infection for the root crops in 1963, for the extreme cold of the 1962–63 winter will prevent aphids over-wintering on the stecklings, and, indeed, how many of the stecklings themselves will survive is in doubt.

Our programme of field experiments grows larger while our farm workers become fewer. Fortunately, conditions in the autumn of 1961 favoured field work and the experiments were all planted in good time, but harvest was more difficult. Cold wet weather delayed the start of the cereal harvest until late August and all grain had to be dried; all was in by the end of September, but only because of the willingness of the farm staff to work much over-time and every Saturday and Sunday. Some barley crops were patchy and, particularly on the lighter land at Woburn, suffered from the lack of rain in June, but most wheat yields were good and better than the early appearance of the crops suggested. The reason for the large wheat yields is uncertain, but neither the aphis-transmitted yellow dwarf virus nor the fungus disease, take-all, were as prevalent or severe as they sometimes are. That barley was lacking water was convincingly demonstrated in the irrigation experiment, where the equivalent of 3 in. of rain increased yield from 24 to 40 cwt/acre, the largest response ever obtained at Woburn with this crop.

Potatoes were lifted in good conditions in October. Blight developed during the rainy spells in August and September, and once again was controlled better by spraying with triphenyl tin acetate than with copper oxychloride. The performance of copper oxychloride was improved by formulating it with a wax emulsion, but even so, the largest increase in tuber yield of King Edward and Ulster Supreme sprayed twice was little more than half that obtained with the tin compound. The benefits from fungicidal sprays cannot be assessed simply by measuring effects on yields of tubers at harvest, for they also depend on how the sprays affect the proportion of tubers that become infected, but in this respect, too, the tin compound was superior to copper and gave fewer blighted tubers. With varieties such as King Edward, in which the tubers are highly susceptible, prolonging the life of infected haulms can do harm as well as good. For instance, although the maximum yield of 17 tons/acre in one experiment with King Edward, from plots sprayed first with dithio-carbamate and twice later with copper oxychloride, was 2·4 tons more than from unsprayed plots, there were 2·6 tons/acre of blighted tubers from the sprayed and 1·6 from the unsprayed. Plots sprayed with these fungicides and with acid before blight had affected half the foliage yielded 1 ton/acre less than plots where the haulm was not killed with acid, but they had only 1 ton of blighted tubers, and so gave the largest yield of sound tubers.

Most of the other root crops were also got in, and some winter wheat was sown, during the good weather of early autumn, but some beet and mangolds were lost when snow and frost arrived unseasonably early in

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November and persisted unusually long, so the end of the year arrived with our programme of field work far from complete.

The use and abuse of toxic chemicals. The last 25 years has seen an ever-increasing number of chemicals used in agriculture and horticulture as weedkillers or pesticides, and it is no coincidence that this period has also seen great increases in production, both per acre and per person employed. Some have also been used extensively outside agriculture, with such diverse consequences as the disappearance of the unsightly fly-papers of old and the rapid increase in human populations in countries where death rates have been diminished by the control of malaria or other insect-borne diseases. What the total consequence will be no one can foresee, but it is clear that if numbers of people continue to increase at current rates much more food must be produced unless people are to starve. It is not obvious how this can be produced except by extending to countries where yields are small and food is scarce the methods that produce large yields and economically embarrassing surpluses elsewhere. An essential part of these methods is the use of pesticides, for there will be no certain gain from improved manuring unless crops are protected against pests and diseases.

There is a growing volume of protest against the use of pesticides, but despite the dire results forecast by some protestors, their use will increase rather than diminish, for the alternative is predictable without any great feat of imagination as recurrent famine conditions. That toxic chemicals need to be used with great discrimination is evident enough from their name, and it is right to protest against indiscriminate or unnecessary use, but the pictures currently being drawn of the human race being slowly poisoned, while all wild life is destroyed except for flourishing strains of pests immune to all pesticides, seem needlessly alarming. "Back to Nature" is a call that becomes increasingly attractive the more sophisticated life becomes, but it is doubtful whether those who rally to it would welcome changing their current worries about effects of pesticides to worries about whether they were going to have enough to eat.

A common condemnation of toxic chemicals is that they upset the "balance of Nature", and of course if weedkillers and pesticides did not change the flora and fauna where they are applied they would serve no purpose. But agriculture itself, however conducted, is the main disturber of any balance, for it means replacing indigenous vegetation, often consisting of many species, by a single crop. There are many reasons for needing to increase crop yields, but no minor one is that, when agriculture is inefficient, it is profligate in its demand on land. When the cultivator moves in, whether or not he uses pesticides, the wild plants and animals inevitably move out, and only by increasing the intensity of production will it be possible to increase the area where wild life can be left undisturbed. The happy time may come when pesticides will not be needed, perhaps because they will be replaced by biological methods of controlling pests and diseases or because there will be immune varieties of crop plants, but this is still remote. Meanwhile what is needed is increased knowledge so that pesticides can be used with the maximum of benefit and the minimum of risk.

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Much of the work we report on weeds, pests and diseases is done with this aim. We do not welcome a continuing chemical battle, and we seek other methods of control, but often the pesticide is not simply the easiest and most effective way, it is the only way. Of the benefits in increased yields, we describe plenty of examples. But the fact that we advocate the use of appropriate pesticides where they are needed does not mean that we endorse all current practices. The cheapness and success of some toxic chemicals encourages their misuse, for growers who have once had obvious benefits from them are inclined to use them routinely. That some sugar-beet crops were needlessly treated with insecticides in 1962 has already been mentioned; this fact means that the "spray-warning" scheme was less effective than it should be. Such happenings deny a main purpose of our work on the factors that affect the populations and movements of pests, for this aims not only to determine the right time and best ways to apply pesticides but to discover alternative methods of control and to predict when the use of pesticides can be dispensed with at no risk to yields. That crops other than sugar beet were also needlessly treated with pesticides is almost certainly true, though there is little reliable information. However, it is very doubtful whether all the land that received chlorinated hydrocarbons thereby produced larger yields. We again produce evidence of the benefits from these insecticides where wireworms were abundant, with increased yields not only from the wheat crop for which the seed was dressed but also from a second one, but such results will not apply generally, and there is no gain from using these substances on land that does not contain damaging populations of wireworms. Again, although the effect of spraying with herbicides is clearly evident from the very different appearance of cereal crops now from some years ago, whether all the fields that are now sprayed needed to be is open to question. The yield of at least one of ours was not increased, so if the spraying conferred any benefit it will be in the form of a diminished weed population in 1963.

The problem in the use of pesticides is how to keep an indispensable practice from becoming an established ritual, and it is not easy to solve. The fact that unnecessary use is wasteful and increases costs of production is obvious, but the cost is often small compared with the losses growers fear should they forego the regular use of pesticides. Although the other consequences of unnecessary use of pesticides are less tangible, they provide the weightier arguments against it, but they need to be put realistically and not as scare stories that conflict with practical experience. Pesticides have had undesirable side-effects of many kinds, ranging from the tainting of food, through the selection of forms of pests resistant to some pesticides, to the killing of beneficial insects and other animals. While there are any unwanted effects, research on how to avoid them must continue, but meanwhile there is little to be gained by magnifying these effects unwarrantably. That birds have been killed is regrettable, but to suggest they are in danger of elimination conflicts ill with the experience of those engaged in the growing of crops. Indeed, while losses from other causes increasingly diminish because of the use of pesticides, those from birds seem on the increase. Despite costly measures of protection, we again lost experiments in 1962 because of damage by birds, which is indeed the

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main single cause of our field experiments failing to give meaningful results. Similarly, the samples of bees we receive as suspected of being poisoned show that some are, but, as when birds are killed, there is often nothing to show whether this happened when pesticides were being used as recommended or when they were being misused. In 1961 we received 45 samples, of which 33 contained a pesticide, and in 1962 we received 24 samples, of which 16 contained a pesticide. The samples show that more care is needed to avoid harming pollinating insects, but their numbers are not such as to suggest that the survival of bees is being threatened.

Those who rail against pesticides often claim that the result of their use is to kill natural predators that otherwise would have controlled the pests, but this idea will not commend itself to anyone who has seen what happens when he left things to predators in years favourable to aphids. Biological control of pests has had some spectacular successes when predators or parasites have been introduced into a region where a pest was previously multiplying unhampered, but it is only a myth that all common pests are in a state of balance with their predators that ensures economic yields of crops. The effect of predators is often discussed but rarely measured, so a measurement with aphids on beans warrants comment. Aphids were fewer and reached their maximum population later on plants with predators than on plants without; plants with predators also produced nearly twice as many seeds, an average of 17 compared with 8 from plants without predators, but this average must also be compared with the 50 produced by plants kept free from aphids. This result is not quoted to belittle the activity of predators, but to put it in perspective. It has no general application, and in other circumstances or on other crops predators will have greater or smaller effects, but it shows that only a third of the potential yield of these beans was reaped unless the plants were artificially protected against aphids. However, any free assistance in the control of pests is to be encouraged, and one purpose of some of the experiments we report is to seek ways of combining biological with chemical control, by applying pesticides in forms or at times that make them active against pests but harmless to predators.

Bee paralysis. Some of the bees sent in as suspected of being poisoned were victims of a virus disease, bee paralysis, the study of which was much complicated by the fact that many apparently normal honeybees and bumble bees proved to be virus-infected. This virus when injected into or fed to other bees from the same colony causes acute paralysis, the bees dying shortly after first showing symptoms. Apparently normal bees also develop acute paralysis when infected with various foreign materials, which apparently stimulate the small amount of virus already present to multiply and become lethal. However, this virus, which morphologically resembles some of the viruses that infect flowering plants or higher animals, is not the cause of naturally occurring bee paralysis; although it rapidly kills injected bees or those that eat large amounts of it, it seems innocuous to bees living their ordinary lives. Bees that contract paralysis naturally contain a second virus, which has particles of a type different from any previously described; this is also lethal but kills more slowly, and as

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naturally diseased bees also do not die until several days after they first show symptoms, this virus seems the probable cause of common bee paralysis.

Soil-borne viruses. Soil-borne viruses were found damaging several crops not previously known to be affected by them, and it seems they may be more important and prevalent than as yet appreciated. Most such viruses yet encountered in the United Kingdom are transmitted by nematodes, some by species not previously described or recognised. Neither the nematode vectors nor the viruses they transmit are likely to be eliminated by changing crop rotations, for many different crops and weeds of arable land are susceptible, so it is fortunate the vectors are susceptible to nematicides currently used to kill such direct plant pests as potato-root eelworm. Indeed, fumigating infested land promises to have longer-lasting effects against the vector species, which multiply much more slowly than the potato-root eelworm, and one fumigation seems likely to protect susceptible crops for several years.

The most widespread of soil-borne viruses, tobacco necrosis, is fortunately less damaging than the others, because it rarely infects plants systemically. It also differs from the others by not having a nematode as its vector, and we confirm the discovery in the United States of America that it is transmitted by the fungus *Olpidium brassicae*. We also have much evidence suggesting that some strains of this virus probably exist as nucleic acid in infected plants instead of in the form of the stable nucleoprotein particles typical of other strains. These other strains are readily transmitted by inoculating healthy plants with sap from infected ones, but the unstable ones are not, for they are inactivated by the enzyme ribonuclease in sap, and infective extracts are obtained only by using methods of extraction that prevent the enzyme from acting on them.

Farmer's-lung hay. It has long been known that those who handled mouldy hay were liable to lung disorders, as also are cattle to which it is fed, but the cause has not been known. To seek it we have been baling and stacking hay at widely different moisture contents, and studying the microbiological and chemical changes that produce hays with components that react with the serum of people who have suffered from Farmer's lung. The cause seems to lie in the *Actinomycetes* sp. that grow in wet hay that heats to 40°; these are the last invaders after other micro-organisms have first multiplied and made the hay both hot and alkaline, and they can be avoided by not baling or stacking hay containing more than 20% water.

Work with soils. More than 1,400 square miles were mapped in various parts of the country in continuation of the primary soil survey, and an additional 350 square miles were surveyed for special reasons, a considerable increase over previous years. One of the special surveys elucidated the reason for cereal crops failing on some shallow soils in Lincolnshire. Typically, large areas of crop become yellow and shrivel in June, but with lines or strips of normal plants. Diagnosis was first confused by the presence of take-all disease, but eliminating that still left miserable crops,

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as did supplying nitrogen and magnesium in which the crops were also deficient. A detailed soil survey showed that the areas where the crop withered have a continuous limestone pavement at a foot below the surface, whereas in the strips carrying reasonable crops the pavement is shattered and the soil is much deeper. The cause of the crops failing seems to be simply drought, for the shallow soils have so little water-holding capacity that they can support vigorous crops only when they receive enough water to compensate for transpiration and evaporation, and the rain during the springs of recent years has been inadequate.

The work we report on soils deals with many problems as varied as the structure of soil minerals, the mechanism of podzolisation, the natural radioactivity in soils, the changes in soil organic matter, the way plant nutrients are held, how water moves and the factors that affect the stability of soil crumbs. Work on the physical chemistry of clays suggests an important role of aluminium in determining their behaviour. When an acid soil is neutralised aluminium is displaced and seems to form complex ions that interact with the edges of clay crystals. This new theory explains some previously puzzling behaviour of clay suspensions, but whether it has implications in such agricultural matters as the effect of frost on soil, the stability of soil structure or the performance of implements, it is too soon to say.

Manures and fertilisers. Whereas we have often recorded increased yields from the combine-drilling of nitrogenous fertilisers, most workers elsewhere have not. The reason for the difference seems to be that our tests were made with ammonium sulphate, whereas other workers used nitrogen in other forms. This year we compared several nitrogenous fertilisers, and only ammonium sulphate gave larger yields of barley when combine-drilled than when broadcast. Placing the fertiliser beside the seed gave no better yields than combine-drilling with ammonium sulphate, but it did with urea, which damaged seedlings when combine-drilled, and gave consistently large yields only when side-placed, presumably because this diminished both damage to the germinating seeds and loss of ammonia to the air. The yields of kale and grass were increased more by fertilisers given as solids than as liquids.

We report the results of even more experiments than usual with organic manures, for almost 200 done some years ago have now been analysed. Effects on crop yields were almost all attributable to the amount of plant nutrients the manures contained; the amount of organic matter as such was unimportant, for sewage sludge contains much more than farmyard manure but increases crop yields less. The few results not readily interpretable in terms of nutrient supply were with farmyard manure, which with many crops, and vegetables especially, was much superior to other organic manures. To what extent this extra benefit from farmyard manure reflects physical effects on the soil, or the amount of and manner in which it supplies potash, is uncertain. For example, at Woburn farmyard manure has consistently produced greater yields of potatoes and sugar beet in the ley–arable experiment than those produced by mineral fertilisers, but this year, when the amount of potash given to the other plots was greatly

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increased, the difference between the yields on these and the others was much diminished. However, as explanations for some actions of farmyard manure are found, new phenomena appear, and this year there was one with the potatoes grown on part of Barnfield, where mangolds and sugar beet have been grown continuously for more than 100 years and have yielded much the same with complete mineral fertilisers as with dung. The doubts that were expressed about the wisdom of growing potatoes proved unfounded in the conditions of 1962, but tuber yields of 18 tons/acre exceeded even the most optimistic expectations. Such yields came only from the plots that have received dung for more than 100 years, but some plots that have received only mineral fertilisers produced 14 tons. On both kinds of plots the potatoes responded greatly to nitrogen; without extra nitrogen, the dung plots outyielded the others by 5 tons and with 1·8 cwt nitrogen per acre they outyielded them by 3·5 tons.

Computation. The demand for computation slowed this year, and although more surveys than usual were analysed, the fact that two computers were operating allowed all requests to be met with little delay. Considerable progress was made in preparing general programmes for the Orion computer, which is now promised for delivery in August 1963. As usual, members of the Statistics Department collaborated with workers in the United Kingdom and overseas on many different kinds of problems, mostly agricultural, and these ranged from an analysis of British wheat yields last century to a serological survey of foot-and-mouth disease in Tierra del Fuego, but were as diverse as a survey of road traffic and the analysis of measurements on barnacles and the teeth of apes. Although the work of other departments ranges less widely, that it also is diverse will be evident from the various subjects already mentioned in this general report, but these fall far short of an adequate indication of what is described in the departmental reports and articles that follow.

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