COMMONWEALTH OF AUSTRALIA

INSTITUTE OF SCIENCE AND INDUSTRY

SECOND

ANNUAL REPORT

OF

THE DIRECTOR

For the period from the 1st July, 1922,

to the 31st December, 1923

MELBOURNE
1ST FEBRUARY, 1924

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(Covering Letter.)

Commonwealth Institute of Science and Industry,
314 Albert-street,
East Melbourne.

The Hon. AUSTIN CHAPMAN, M.P.,
Minister for Trade and Customs,
Melbourne, 1st February, 1924.

DEAR SIR,

In accordance with the provisions of the *Institute of Science and Industry Act* 1920 (Section 18), I beg to forward herewith my Second Annual Report covering the period from the 1st July, 1922, to the 31st December, 1923.

Section 19 of the Act provides that the Report shall be laid before both Houses of the Parliament within 30 days after the receipt thereof if the Parliament is then sitting, and, if not, within 30 days after the next meeting of the Parliament.

Yours faithfully,
(Signed) G. H. KNIBBS,
Director.

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COMMONWEALTH INSTITUTE OF SCIENCE AND INDUSTRY.

SECOND ANNUAL REPORT

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THE DIRECTOR

FOR THE PERIOD FROM THE 1ST JULY, 1922, TO THE 31ST DECEMBER, 1923.

I.—INTRODUCTORY.

The steps which were taken by the Commonwealth Government for the establishment of a Commonwealth Institute of Science and Industry dating from January, 1916, were outlined in the first Report of the Director. Pending the creation of the permanent Institute a temporary Advisory Council was appointed, and held its first meeting in April, 1916. The movement was enthusiastically supported by leading industrial and scientific men throughout the Commonwealth, and great public interest was unquestionably awakened.

In establishing the temporary body the main object was to prepare the ground for the then proposed permanent Institute. By the middle of 1917 the Advisory Council had completed the work for which it was specifically appointed. It informed the Commonwealth Government accordingly, and urged the establishment forthwith of the permanent Institute. At the request of the Government, however, the temporary body continued its existence and in its self-sacrificing labours for a further period of over three years.

The Advisory Council had neither laboratories nor research staff, nor had it apparatus of its own. Moreover, the Government was not prepared to authorize work of a continuous or permanent nature to be undertaken by the temporary body. The Advisory Council was thus greatly limited as regards any programme for systematic work. Its resources were inadequate, and its executive authority and control for carrying on its work were insufficient. It was then believed that the need for its temporary character would require to continue for a few months only, but it carried on its work as a temporary body for no less than five years. Despite the great difficulties under which it laboured, it carried out a large amount of valuable work, as indicated in its Reports and in the first Annual Report of the Director of the permanent Institute. It had always been understood that the permanent Institute, when created, would be adequately provided with resources, that being indicated in the Report of the initial conference convened by the Prime Minister, the Right Hon. W. M. Hughes, P.C., LL.D., M.P., for the purpose of preparing a scheme for the organization of the Institute.

The Prime Minister outlined the scope of the work of the Institute in his address to that Conference, stating that " the objective was to apply to the pastoral, agricultural, mining, and manufacturing industries the resources of science in such a way as to more effectively develop our great heritage, and that the attainment of this would involve a central laboratory with a staff of the best scientists, who would have at their disposal ample facilities for original research work." He said also " that upon the calibre of these men the usefulness of the institution would depend."

Giving point to his comment he said, further, that " provision would be required for :—

" (*a*) A Bureau of Standards for the purpose of investigating and testing standards and measuring instruments, and determining the physical constants and properties of material . . . . . including the comparison and verification of weights, measures, thermometers, &c., with Commonwealth standards.

" (*b*) Investigation and industrial research . . . . . problems associated with our great primary industries, pastoral, agricultural, viticultural, the mining of coals and metals, and the metallurgical treatment of the latter.

" (*c*) The chemical and physical study of problems bearing on the secondary industries with a view particularly to the improvement of quality of manufactures, the reduction of the cost of production . . . the utilization of waste materials."

In regard to the scale of operations, the Prime Minister urged that we should " not be pessimistic," but approach the question with " a heart full of courage," and added that " they were prepared to go up to £500,000 . . . . they would spend as much as was necessary. He recognised also that we had to ' make up leeway ' and put the scheme on a sound footing."

II.—STATUTORY FUNCTIONS OF THE INSTITUTE.

The Act to establish the permanent Institute was passed in September, 1920, and the Director appointed on 18th March, 1921. From the beginning it had been assumed by the scientific and industrial men who had lent their aid to the labours of the temporary Institute, that, as soon as the permanent Institute was established, it would be provided with the necessary staff and resources to enable it to perform the whole of its statutory functions, these being in accord with the Prime Minister's original indication. Set out at length in the Act, they are as follow :—

(*a*) The initiation and carrying out of scientific researches in connexion with, or for the promotion of, primary or secondary industries in the Commonwealth ;

(*b*) The establishment and awarding of industrial research studentships and fellowships ;

(*c*) The making of grants in aid of pure scientific research ;

(*d*) The recognition or establishment of associations of persons engaged in any industry or industries for the purpose of carrying out industrial scientific research and the co-operation with and the making of grants to such associations when recognised or established ;

(*e*) The testing and standardization of scientific apparatus and instruments, and of apparatus, machinery, materials, and instruments used in industry ;

(*f*) The establishment of a Bureau of Information for the collection and dissemination of information relating to scientific and technical matters ; and

(*g*) The collection and dissemination of information regarding industrial welfare and questions relating to the improvement of industrial conditions.

The Director shall, as far as possible, co-operate with the existing State organizations in the co-ordination of scientific investigations, with a view to—

(*a*) the prevention of unnecessary overlapping ; and

(*b*) the utilization of facilities and staffs available in the States.

The gratuitous labours of the scientific men and industrial experts of Australia, very generously undertaken during the existence of the temporary Institute, could not be expected to continue when a permanent Institute was created with the statutory functions above outlined. These disclose the fact that the scheme for the establishment of the Institute, sanctioned by Parliament, is wide in its scope. It is the first instance in which a Government has created a single organization charged with the duty of carrying out investigations covering practically every branch of applied science and of industry, both primary and secondary. In other countries large separate institutions have been established from time to time and developed effectively to deal with the different branches of science, pure or applied. In the United States of America, for example, there are the Bureau of Standards, the Bureau of Mines, the Smithsonian Institution, and the Department of Agriculture, with its numerous scientific and technical bureaux.

III.—WORK IN PROGRESS.

Contrary to the statements which had been made and therefore also to the expectations of all those who had whole-heartedly supported the movement to establish the Institute, and who had given their services gratuitously to the temporary body, the permanent Institute has not even yet been provided with the funds and resources necessary to enable it adequately to perform its statutory functions.

The total vote for the Institute in 1922–23 was £20,907, but this included a sum of £1,007* for the establishment and equipment of a Forestry School (a matter which does not strictly come within the scope of the Institute's

* Not expended.

functions), £4,000 for the prickly pear investigations, and £2,000 for the paper-pulp work. Excluding these special grants, the total vote was, therefore, only £13,900.

The total vote for 1923–24 was £21,356, but this again included £4,000 for the prickly pear investigations, £1,000 for paper-pulp, £2,000 for the Pan-Pacific Science Congress, and £1,500 for an investigation of bunchy-top disease in bananas, leaving a net vote of only £12,856.

Thus, excluding the special grants indicated, *there was actually a decrease of over* £1,000 *in the sum provided for the current financial year 1923–24* as compared with that for the preceding year.

Obviously, with a staff of only a small number of experts at head-quarters, and with so small an annual vote, it is quite impossible to cover the whole prescribed field even in the most superficial way. The Institute's existing resources and funds are, in short, wholly insufficient to deal effectively and comprehensively even with single important branches of applied science in Australia. Of the sum of £12,856 available in 1923–24 (excluding the special sums specified above), about £6,000 is required for administrative expenses, the Bureau of Information, salaries, contingencies, &c., at the Institute's head-quarters, leaving a sum of less than £7,000 available for researches into all the scientific and technical problems affecting both our primary and secondary industries.

The result has been that it is necessary to severely restrict the Institute's work to a few special investigations and to devote practically the whole of the available funds to the continuation of work already initiated by the temporary Institute. With one or two minor exceptions, it has, consequently, not been practicable to commence any new investigations, in spite of the very large field of work requring attention and of the fact that the Institute has received special requests from various authorities to undertake the investigation of various problems of great importance to the welfare of Australia and the development of her industries. (*See* Sections V. and VI. of this Report.)

Many urgent recommendations have been made by the Director to the Government to provide additional funds in order to enable experimental work on pressing problems to be undertaken, but, so far, these recommendations have not been approved.

It should be noted that the Institute of Science and Industry Act specifically provides that the Institute shall establish—

(*a*) a Bureau of Agriculture ;
(*b*) a Bureau of Industries ; and
(*c*) such other Bureaux as the Governor-General determines.

Recommendations have been made to the Commonwealth Government that funds be provided for the appointment of the Chiefs of the Bureaux of Agriculture and Industries, respectively, and for the creation of the nuclei

of these two Bureaux. Effect has not, however, yet been given to these recommendations, and it has consequently not been possible to carry out the provisions of the Act relating to these Bureaux.

The experimental work in progress in the Institute during the period covered by this Report is shown in the following statement:—

TABULATED STATEMENT OF EXPERIMENTAL RESEARCH WORK IN PROGRESS.

Investigations.	Bodies co-operating with Institute.	Present Position.
1. Prickly Pear ..	New South Wales and Queensland Governments	Results already obtained in laboratory indicate that certain parasitic insects and fungus diseases have now been established, and that, provided they are as effective in the field as they are in the laboratory, complete biological control of the prickly pear pest may ultimately be expected. Steps are being taken to liberate certain species of insects.
2. Pottery ..	Victorian Mines Department and Ballarat School of Mines	Nearing completion. Successful methods evolved on laboratory scale for production of white earthenware from local raw materials are likely to be adopted industrially on commercial scale. Causes of discolouration of semi-vitrified ware ascertained; method of eliminating these causes is being investigated.
3. Paper-pulp ..	State Forestry Departments and Aust. Paper and Pulp Co. Ltd.	Results show that there is a probability of the manufacture of paper-pulp from Australian timbers being sucessfully established on commercial scale. Semi-large scale experiments carried out in co-operation with the Aust. Paper and Pulp Co. Ltd., at Geelong. Further tests in progress.
4. Blow-fly ..	Queensland Pastoralists and Queensland Department of Agriculture	Valuable results obtained *re* jetting and increasing arsenical strength.
5. Tannin Survey	State Forestry Departments	Valuable information obtained *re* new sources of tannin hitherto wasted. Work in progress.
6. Cattle-tick Dips	New South Wales and Queensland Agricultural Departments	Experiments to ascertain strength of dips, periods for dipping, &c., in progress.
7. Viticultural Investigations	Victorian Department of Agriculture, State Rivers and Water Supply Commission, Mildura Vineyards Protection Board	Successful method devised for treatment of "black spot," so that this disease is now largely under control. Preventive treatment adopted for Fruit-moth pest. Other chemical and biological investigations in progress.
8. Seed Improvement	Agricultural Departments in each State	Classification and description of wheats, barleys and oats completed with results that work of plant breeders facilitated, undesirable varieties eliminated in favour of more prolific and disease-resistant varieties.

A.—Agricultural and Pastoral Industries.

1. **General.**—The loss to the agricultural and pastoral industries of Australia, and to the secondary industries dependent on them, caused by diseases, pests, and parasites, amounts to millions of pounds per annum. Nearly all the serious pests have been introduced from other countries, and many have now spread over a great part of Australia or even the whole; thus the work of eradication is costly and will take a number of years.

From plant-diseases alone the annual loss has been estimated at £5,000,000. An estimate of the loss from the sheep-fly pest gives as much as £4,000,000 in a bad year. Prickly-pear already covers an area in Australia greater than the total area under all forms of cultivation. During the past fifteen years New South Wales alone has expended £600,000 in an attempt to keep back the cattle-tick pest. The loss from fruit diseases due to fungi is estimated at £1,000,000 annually.

An efficient campaign against any of these pests requires that existing knowledge shall be supplemented by the results of a considerable amount of scientific investigation, this being reached by the co-ordination of effort in the various States. For example, it is ordinarily necessary that the life-histories of the various pests shall be fully understood.

In general, before any investigation is undertaken, the most complete information from all sources should be collected by experts in the particular branch of science concerned. In this way the existing state of knowledge and the extent to which the problem has already been solved is disclosed.

For example, in several of the investigations already undertaken by the Institute (*e.g.*, cattle-tick pest, worm-nodule disease in cattle, &c.) a considerable amount of investigation had already been carried out both in Australia and in other countries. Thus, before the Institute could lay down appropriate lines for further research it was desirable that the whole position should be thoroughly reviewed by experts. A critical examination of the entire problem, and of the existing state of knowledge in regard thereto, is an indispensable preliminary to effective research.

This preliminary involves considerable labour, and the existing resources and staff of the Institute are inadequate to permit of its being undertaken over a sufficiently wide area. Particularly is this the case in regard to problems affecting the agricultural and pastoral industries. In dealing with these as they come before the Institute, the initiating of research work on specific matters would be a very unsatisfactory and inefficient method of procedure. The whole field should first be comprehensively studied. But this is not practicable until at least the nucleus of a Bureau of Agriculture, as required by the Institute of Science and Industry Act has been established.

If in Australia the example of other countries be followed, comprehensive investigations will always be carried out with a view to formulating effective, practical, and economical measures for the control, for example, of the various pests. In another part of this Report attention is directed to the numerous

requests which the Institute has received to undertake such investigations. But it is unable to comply with many of them, owing to the fact that the necessary funds are not available.

2. **Investigation of Plant Diseases.**—In June, 1921, the New South Wales Department of Agriculture intimated that it was prepared to co-operate with the Institute of Science and Industry in the work of investigating fruit-diseases and would provide a sum of £1,000 if the Institute would provide an equal amount. In September, 1922, a recommendation was made by the Institute to the Treasurer to provide such a sum, but it was stated that no money beyond the amounts already provided in the Estimates could be found. Unfortunately, the proposal was made soon after the commencement of the financial year, and the New South Wales Premier was accordingly informed that no money had been made available for such investigations.

The New South Wales Department of Agriculture considered that an immediate start should be made, and the matter was subsequently placed in charge of a Committee of its own expert officers, who had at their disposal the assistance of 40 fruit inspectors and the use of six (6) Government orchards, where experiments could be carried out.

When preparing the Institute's Estimates for the year 1923–24 this question of co-operation with New South Wales was revived and referred to the Director of Agriculture in that State. A reply was received from him stating that co-operation would have to be on different lines, since the work as originally planned by his Department was now organized on such a scale that it would be unwise to interfere with it in any way.

In December, 1922, the Premier of New South Wales brought under notice of the Prime Minister the need for further investigation to be undertaken on certain serious plant diseases. The request was made "that certain diseases, such as blue mould of tobacco, tomato wilt, and bunchy top of banana should, on account of the serious loss that has resulted from them in more than one State, be treated as a national undertaking in a joint effort on the part of the Federal Government and the State Governments concerned, and that the Federal Government, through the Institute of Science and Industry, should subsidize on a £1 for £1 basis the expenditure of the State Governments in carrying out the necessary investigations. It is recognised that the problems to be faced are sufficiently large to justify the combined attention of the Commonwealth Institute of Science and Industry and the scientific staffs of the State Governments."

While the Institute cannot, of course, act merely as a subsidizing agency without any control of the work, the general nature of the proposals for co-operation were in conformity with the policy adopted by the Institute and already in operation in connexion with the investigations on the prickly-pear pest, the sheep-blowfly and cattle-tick dips. Accordingly the Premier of New South Wales was informed that the proposals had the general approval of the Commonwealth Government, but that the funds available for the Institute did not permit of the extension of its work to the problems suggested. He was also informed that the question of providing increased funds for the

purpose would be considered in connexion with the preparation of the Estimates for 1923–24. Though the draft Estimates submitted by the Institute included provision for this work, no such provision was made in the Estimates presented to Parliament. The result is that though investigations on plant diseases should form an important part of the Institute's functions, and though many requests have been received by the Institute to undertake such investigations, it has been unable, owing to lack of funds, to carry out the work.

(i) *Bunchy Top of Banana.*—Meanwhile the extension of the destruction of banana plantations by the disease locally known in the northern river districts (especially the Tweed River) of New South Wales, as bunchy top, was causing considerable alarm. The need for investigation was brought up in the House of Representatives, and the Minister for Trade and Customs promised to refer the matter to the Institute of Science and Industry. A sum of £1,500 was placed on the estimates for 1923–24, conditionally on New South Wales and Queensland each contributing £1,500 for the first year to the costs of a joint investigation.

The Institute had also received requests direct from growers, to investigate the matter, since the cause was still unknown and consequently no satisfactory treatment had been evolved. It was first brought under notice of the Institute in 1918 by the Tweed Fruit Growers Association, Murwillumbah, and again in May, 1923. The Tweed Fruit Growers Co-operative Company Limited invoked the assistance of the Institute. This company stated that "for some years past the disease has been seriously menacing the banana industry in this State (New South Wales) and southern Queensland, and the efforts of the Departments of Agriculture in both States have hitherto been powerless to check it. In the opinion of the Directors, the highest possible scientific knowledge should be brought to bear on the subject in order to save a primary industry worth annually £1,000,000."

The disease began to spread into Queensland. A deputation of banana growers waited on the Queensland Minister for Agriculture, and asked for a buffer area 20 miles south of the Brisbane River to be proclaimed. The Governments of New South Wales and Queensland and the Commonwealth agreed that a joint investigation was desirable, but owing to various causes, agreement as to a scheme acceptable to all parties was not reached until recently.

Each of the three parties, viz., the New South Wales and Queensland Governments and the Institute has agreed to nominate an independent scientific representative (*e.g.*, a University professor) to form an advisory committee of three, to inquire fully into the investigations that have been made in the past, consider the existing position, and make recommendations as to what investigations are necessary, and how, where, and by whom they might best be carried out. The committee which is to present its report by the 1st March, 1924, consists of the following:—

Professor T. G. B. Osborn, D.Sc., Professor of Botany, Adelaide University, representing the Institute of Science and Industry.

Professor R. D. WATT, M.A., B.Sc., Professor of Agriculture, Sydney University, representing New South Wales.

Professor E. J. GODDARD, B.A., D.Sc., Professor of Biology, Brisbane University, representing Queensland.

(ii) *Tomato Wilt.*—The disease of tomato plants popularly known as wilt, or spotted wilt, caused considerable damage to the tomato crops in Victoria in 1919 and 1920. The cause is not definitely known, but certain evidence indicates that it is probably bacterial. It has also spread through New Wales and Queensland, and so far plant pathologists have failed to discover the cause or to prescribe an efficient remedy.

At the Annual Conference of the Australian Association of Nurserymen and Seedsmen, held in Melbourne in November, 1920, a resolution was passed urging the Commonwealth Government to provide funds for the investigation of this tomato-disease in the same way as was done to investigate bitter-pit in apples. This resolution was sent to the Commonwealth Treasurer in March, 1921, and was referred by him through the Minister for Trade and Customs to this Institute for consideration.

Representatives of the Association had discussed the matter with officials of the various State Agricultural Departments, who considered it very desirable that some such steps be taken, as the amount of money that they had available for the purpose was too small to carry out the thorough investigation required.

The Victorian Department spent £750 investigating the problem at Bendigo, Echuca, and Burnley, but was not successful in ascertaining the cause. It was found that tomatoes grown in sterilized soil and enclosed in a very fine mesh cheese cloth screen were apparently free from disease. The disease is prevalent in all the States of the Commonwealth, as well as in South Africa and United States of America. In the latter country the Bureau of Plant Industry has been working at the disease for a number of years. The Victorian Superintendent of Agriculture stated that it would be a great advantage if his Department could obtain the services of a properly qualified expert to give his whole time to the problem.

The whole question of the Commonwealth policy in the matter of providing adequate funds for the Institute to undertake such investigations was submitted to the Commonwealth Treasurer in May, 1921. The Treasurer was of the opinion that this investigation might be carried out by some State officer, working in conjunction with the Institute, and that the matter would have to wait until the next year's Estimates.

In November the Treasurer was asked to make available a sum of £500 for half of the financial year 1921–1922, and thereafter to provide £1,200 per annum for three years. The Minister for Trade and Customs approved of this proposal, but in January, 1922, the Treasurer stated that he was unable to find any money for the investigation.

The Nurserymen and Seedsmen had by resolution at their annual conference (November, 1922) again approached the Prime Minister on the subject of providing money, and were informed that their representations would receive

consideration. When the matter was again submitted to the Treasurer, it was once more postponed for the following Estimates 1923–24, but then again no funds were provided.

(iii) *Blue Mould of Tobacco.*—This disease is the greatest hindrance to tobacco-growing in Australia. The cause is a fungus *Peronospora hyoscyami* (de Bary), and it will often destroy whole beds of seedling tobacco plants. It has caused considerable loss for many years in New South Wales, and this year has become very prevalent and destructive in Victoria.

Blue mould was one of the three diseases mentioned by the New South Wales Premier in his letter (December, 1922) to the Prime Minister (see page 8) asking for a subsidy for investigations on certain serious plant diseases, and the New South Wales Premier suggested that if funds permit, an extension of the work should be brought about by establishing research stations in country districts where the diseases referred to are prevalent, *e.g.*, at Murwillumbah for bunchy top of banana, and at Tamworth and Bathurst for blue mould of tobacco.

In January, 1923, the New South Wales Premier was informed that no funds were available for the work, but that the question of providing increased funds would be considered in connexion with the Estimates for 1923–24.

The New South Wales Premier again asked the Commonwealth Prime Minister in August, 1923, to contribute towards the costs of investigating blue mould of tobacco and tomato wilt. The matter was included in the definite proposals for co-operative investigation submitted to the Minister for Trade and Customs and the Commonwealth Treasurer, in order to give effect to the agreement reached between the State Premiers and the Commonwealth Prime Minister at the Inter-State Premiers' Conference in May, 1923. (*See* Sections IV. and V. of this Report.)

The Federal Treasurer has intimated that no funds in excess of the Institute's Vote for 1923–24 are available. The Institute is thus unable to co-operate with the States in the investigations, although—as already stated—it has been especially asked to do so.

(iv) *Citrus Investigations.*—At the beginning of 1921 the disease of the Emperor Mandarin known as Brown Spot, caused by the fungus *Colletotrichum glœosporioides* was brought under the notice of the Institute by the Fruit Growers' Association of New South Wales, owing to the alleged failure of the Agricultural Department to cope with the disease, and also on account of the great loss caused by it.

The Association offered to place orchards at the disposal of the Institute, but was unable to contribute towards the cost of research work. It approached the New South Wales Department of Agriculture on the matter, and in June, 1921, that Department offered to co-operate and contribute on a £1 for £1 basis. As no funds were available on the Institute's vote, the Commonwealth

Treasurer was asked in September, 1922, to make £1,000 available in order to enable the offer to be accepted. This recommendation was not approved. A similar request for research to be undertaken was made by the Australian Citrus Association, of which the Mildura District Citrus Co-operative Association Limited was a section, and which offered to provide experimental plots.

This was followed in December, 1922, by a proposal from the New South Wales Water Conservation and Irrigation Commission, that the Murrumbidgee Irrigation areas might be made the centre for citrus research on a plan similar to the vineyard research at Mildura. There were nearly 4,000 acres of citrus trees on the area, and the active co-operation of the following bodies was promised :—(*a*) The Commission through its Research Bureau, (*b*) the local branch of the New South Wales Fruit Growers' Association, (*c*) the co-operative societies at Mirrool, Griffith and Leeton.

Some outstanding problems for research were stated, and the Commission offered to contribute up to £1,000 for the first year, to set aside an experimental area, value at £1,500, to take steps to appoint a suitably qualified investigator, and to ascertain whether the Department of Agriculture of New South Wales and the Central Citrus Association would co-operate and contribute towards the cost. The Institute's recommendations for additional funds for this work were not approved, but it has recently been found practicable to set aside a sum of £500 from the sums already provided on the Estimates for 1923–24. Arrangements are accordingly being made to initiate the experiments forthwith in co-operation with the New South Wales Water Conservation and Irrigation Commission.

3. Investigation of Stock Diseases.—One of the most important branches of work which it was intended should be taken up by the Institute is the investigation of stock-diseases. With the small funds available the Institute has so far been able to carry out only certain limited investigations in co operation with the State Agricultural Departments, Universities, and agricultural or pastoral bodies, &c., *e.g.*, (*a*) cattle-tick pest, (*b*) sheep-blowfly pest, (*c*) worm nodules in cattle, (*d*) tuberculosis in stock.

From its commencement the Institute has, however, received various requests to carry out investigations on other problems coming within the scope of its intended functions. These requests have come from all the States, from Government Departments, corporations and public bodies, many of which have offered funds for co-operative research work.

A selected list of such proposed investigations is given elsewhere in this Report, but two of them deserve special mention, viz. :—(i) The Kimberley horse disease, and (ii) the buffalo or horn fly.

(i) *The Kimberley Horse Disease.*—This disease was first brought under notice in July, 1918, when a petition from a number of Kimberley pastoralists was presented to the Western Australian Minister for Agriculture and the co-operation of this Institute was suggested. In December, 1919, a committee of pastoralists, which met in Perth to determine and advise upon means to bring about the

closer pastoral settlement of the Kimberley and north-west divisions, again suggested that the Institute might investigate the disease, which was stated to be the most serious hindrance to settlement.

The Premier of Western Australia communicated with the Institute through the Prime Minister's Department requesting advice on the nature, extent, and cost of such an investigation, suggesting the nomination of an expert and inquiring whether part of the cost could be defrayed from the funds of the Institute, in view of the large area concerned and the relation of the disease to the Northern Territory. Reports indicated that in West Kimberley 30 per cent. of horses died every year, and in East Kimberley from 3 to 6 per cent. died.

In February, 1920, a joint investigation was proposed, the Commonwealth Government and Western Australia each to contribute up to £500 on a £1 for £1 basis. It was considered that the investigation would take several years. A proposal was also made that pastoralists might be asked to contribute to the research fund at the rate of 1s. per head of horses owned by them. These proposals were not approved, and no money has been provided.

The following summarized information has been collected from various sources and indicates that the disease apparently exists throughout the northern half of Australia.

Judging by descriptions of the symptoms—as related by stockowners—the same disease as that occurring at Kimberley seems to occur in the Northern Territory, where it is popularly designated "Walk-about Disease" from the most characteristic symptoms, and even in parts of Queensland where it is termed "Birdsville Disease," from the locality in which it first attracted attention. Its occurrence has been reported for many years, but comparatively little scientific investigation has been carried out regarding its pathology. It was commented upon by Dr. J. A. Gilruth as far back as 1911, who, while engaged in a scientific mission to the Territory, made exhaustive enquiries, though, it appears, he was not able to personally examine any cases. He inclined to the opinion that the symptoms pointed to the disease being of the same nature as that known as "Winton Disease" in New Zealand (the primary lesion of which is a chronic inflammation of the liver) and of "Bottom Disease" in America, the pathology of which is similar. Dr. Gilruth had demonstrated by experiment that the New Zealand disease was due to the repeated ingestion of *Senecio jacobœa*, and since then it has been shown that the same plant, and others of the same species, are responsible for serious mortalities of horses and cattle in United States of America, Canada, South Africa, and elsewhere. He therefore suspected the "Walk-about Disease" to be of the same nature and to be due to similar causes.

Lewis was able to prove later that in a typical case the liver was the chief seat of pathological change, the condition being a cirrhosis or chronic inflammation. Since then, chiefly because of the difficulty of finding cases before death in unfenced country, where horses roam at large, there has been little or no further investigations.

The disease is generally, if not always, fatal after the onset of symptoms, the duration of which may be from a day to a week or even more. The symptoms are those of cerebro-spinal disturbance, characterized by some inco-ordination of the locomotory muscles, a vacant expression, inattention to surrounding objects, and a desire to wander aimlessly, but more or less in a direct line, heedless of obstacles. The consequence is that animals affected in the bush suffer bruises and abrasions of the head and limbs, and are frequently found dead.

It is difficult to estimate the extent of the losses, but to the presence of the disease is attributed the fact that on quite a number of stations the horses do not increase in number, and that on some they have materially decreased.

There is no reason to believe that the disease is contagious. At all events, where an animal has been introduced to a locality in which the disease has hitherto been unknown, and has later developed symptoms, there has been no indication of spread.

It is the most serious drawback, however, to successful horsebreeding over a large area of Northern Australia, and calls for careful investigation.

(ii) *The Buffalo Fly.*—The menace of this fly was reported to the Minister for Trade and Customs early in 1920 by Dr. J. A. Gilruth, formerly Administrator of the Northern Territory. He referred to it as a serious pest, and stated that it was only a matter of time, unless preventive measures were taken, before the fly would spread to other parts of Australia. Dr. Youngberg, Government Veterinary Officer in the Philippines, also reported that the buffalo fly will prove a great menace to the cattle industry throughout Australia, unless it is tackled promptly and with determination. He suggested that one or more highly trained entomologists should be detailed exclusively to the work. Known means of coping with it, such as the use of sprays, dips, and smears, are quite impracticable, and even useless. It will be necessary to ascertain its distribution, and to discover and introduce, if possible, one or more parasites that will effectively attack the fly, either in the adult stage, or in some stage during its development. At the same time a search should be made for scavenger beetles to attack the dung sheltering the larvæ and pupæ.

Information was obtained by the Institute from the Philippines, Hawaii, and India, which confirmed that already available, and similar procedure was recommended.

The fly *Lyperosia exigua* (de Meijere) occurs in the Northern Territory and possibly extends into Queensland. The same species occurs in Java, India, Central Asia, and a closely related form (*Lyperosia irritans* Linn.) in the Philippines, United States of America, and Europe.

It is a biting fly about the size of a common house-fly, and its repeated bites produce an irritation which causes the animal to rub against a post or tree until a raw surface is produced. Horses and cattle are generally attacked on the belly, brisket (under part of neck), flanks, eyes, withers, &c., lesions on the former being generally produced on the first three places, whereas lesions of cattle are usually on the neck and corners of the eye. The Brahman cattle

are practically immune from attack. Cattle not only lose condition through irritation and loss of blood, but there is considerable damage to the hides, and the quality of the meat is much reduced owing to its dark colour and damaged appearance. The fly lays its eggs in the fresh dung of the animals, and when hatched the larvæ burrow through and pupate immediately below the dung. The rapid drying out and the scattering of this protection would help to reduce the numbers hatching out.

Early in 1922 a recommendation was made by the Institute for the appointment of a qualified investigator, but no funds were made available. In 1923 a reply to further representations, when a scheme of research was outlined, the Institute was informed that no funds were available, but that the matter should be brought under notice in connexion with the Estimates for 1924–25.

(iii) *Sheep Blow-fly Pest.*—No investigations on this problem have been made in N.S. Wales since the publication of the Director's first Annual Report. Particulars of the joint committee which formerly controlled the investigations were given in that Report, and the results of the work were published in a Bulletin issued by the Department of Agriculture, N.S. Wales, as one of its Farmers' Bulletin Series, viz. :—Sheep-maggot Flies (No. 5) Farmers' Bulletin (No. 144), by W. W. Froggatt, F.L.S., 32 pp., Government Printer, 1922.

This Bulleting summarises the methods of control recommended as a result of the many years of investigation in N.S. Wales. No single method can be relied on to control the pest adequately, but if the methods described in the Bulletin are put into general operation, there is every reason to believe that the seriousness of the pest will be considerably diminished.

In Queensland experimental work was initiated by the Institute in 1917, under a special committee consisting of the following members, viz. :—

The members of Special Committee on Blow-fly Pest in Queensland are as follow :—

S. P. Fraser (Chairman until 1923), Brisbane.

A. H. Cory, M.R.C.V.S. (Chairman, 1923), Chief Inspector of Stock, Department of Agriculture and Stock, Brisbane.

W. G. Brown, Sheep Expert, Department of Agriculture and Stock, Brisbane.

J. B. Henderson, F.I.C., Government Analyst, Brisbane.

W. A. Russell, Dalmally Station, Roma, Queensland.

Early in 1923 this committee suffered the loss of its chairman, Mr. S. P. Fraser, who had devoted a considerable amount of time and energy to the duties of the position. His untimely death is sincerely regretted by all, and his fellow members have placed on record a deep appreciation of his services. His place as chairman has been taken by Mr. A. H. Cory.

The work done during the year consisted of experiments along the following lines :—

(*a*) Jetting large number of sheep with a solution of arsenic (As_2O_3) and soda ash, containing from 0.7 per cent. to 1.0 per cent. arsenic (As_2O_3).

(*b*) Dipping ("showering" and "swimming") with comparatively strong solutions of arsenic (As_2O_3).

(*c*) Jetting and dressing with arsenic (As_2O_3) and oil mixtures.

(*d*) Dressing with crude fuel oil.

A popular account of the Queensland investigations was published in the Queensland *Agricultural Journal* for July, 1922, pp. 12 to 15, and August, 1922, pp. 102 to 104. The first describes the early efforts to combat the fly, and summarises the investigations on traps, poison bags, parasites and natural enemies. The second gives details of the jetting process, the preparation of the solution used, the pressures required according to growth of wool, and the amount of solution recommended. It indicates the results obtained, the costs of jetting and the risks.

(*a*) *Jetting.*—The process of jetting, recommended as a result of the Queensland investigations, has proved to be the most efficient and cheapest method yet devised.

Although experiments were made with solutions containing 1 per cent. of arsenic (even up to 1.5 per cent. without apparent injurious effect on either the wool or the sheep) the strength finally recommended is 0.7 per cent. of arsenic made with 7½ lbs. of grey arsenic (93 per cent. arsenious oxide) dissolved in 100 gallons of water by the aid of 9 lbs. of soda ash. Some form of power-machine is required to force the solution through a hose with a nozzle aperture of 1/16th inch, in a solid jet into the breech of the sheep with a steady pressure that can be varied from 50 to 200 lbs. to the square inch, according to the growth of the wool. Jetting is relied upon to have the following effects:—

1. To cleanse the breech of any maggots, and putrefactive material, if the sheep has been "struck" before jetting.
2. To convert the sheep into a fly trap, because arsenic is absorbed and retained in sufficient quantity in the wool to act as a larvicide for any maggots that might develop therein, subsequent to the jetting.
3. To confer immunity from attack for a minimum period of six weeks, but varying up to three months, depending upon the strength of solution used, and on the weather conditions.
4. To confer immunity throughout the year, and so prevent any necessity arising for the employment of any other method, provided that three jettings per year are given.

It is admitted that the breech alone is protected, but 90 per cent. of fly attacks are in the breech.

The method is now recommended in N.S. Wales, though slight differences in the percentage of arsenic and the pressures have been advised.

The immunity from attack may be due to other causes than mere poisoning of flies and larvæ. The action of arsenic in cleansing the breech of sheep previously attacked suggests that the putrefactive organisms are killed and the chemotactic influences are removed or prevented from further development. As a consequence the female fly is no longer attracted to

deposit her eggs. A similar line of reasoning can be applied to the Queensland claims that the action of arsenic is healing, and not irritating or inflammatory. As a result of the N.S. Wales investigations, a jetting solution containing not more than 0.3 per cent. of arsenic is recommended for the following reasons:—

1. A solution of 0.3 per cent. is sufficient to kill all larvæ present.
2. Stronger solutions might inflame the skin.
3. Any excess of 0.3 per cent. is not only wasteful but injurious.
4. The period for which protection is conferred, depends on the growth rate of the wool, which is on an average one-eighth of an inch per month on a merino sheep.

Inflammation is said to lead to the production of sores and suppuration, and the latter induces fly-attack, and the burrowing in of the larvæ. The subject is one that is worth investigating. A knowledge of the movements of the arsenic on the fibre and in the suint, mainly due to changes in the percentage of water present, especially due to rain, the relation of arsenic to new wool growth after spraying and its presence on, or in the skin, would help to reconcile the two sets of opinions.*

(*b*) *Dipping.*—The protection obtained in previous years by dipping with the shower-dip was still found to be the most suitable and effective in the case of ewes in lamb, weak sheep, and those with six or more months' growth of wool. For other sheep, such as those that are dry and have very little growth of wool, a swim-dip was built, and found to be preferable, being quicker. As it was found that dipping with the ordinary strength of 0.2 arsenic gave little protection from fly attack, the strength was gradually raised, and during the year many sheep have been put through the dip at a strength of 0.5 per cent. arsenic. This gave good protection from fly attack, and so far not a single case of arsenical poisoning has appeared. Owing to the weaker strength of arsenical solution which has to be used, dipping has not given so good a protection against fly attack as jetting, though it is necessary where protection is required for other parts of the body than the breech.

When the sheep are to be dipped they should not be driven or overheated immediately before or after dipping, which should not be after midday in winter nor after 4 p.m. in summer. There is no need to crutch the sheep after dipping or jetting.

Tests were made to determine what effect on the arsenic content of the dip. swimming a definite number of sheep had. The dipping fluid was used in strengths increasing by 0.1 per cent. from 0.2 per cent. to 1.0 per cent. Batches of sheep were put through the swim, and samples of the dip were taken for analyses before and after the swim. Results indicate that there is little adsorption of arsenic by the wool. Further confirmatory tests are to be made.

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* There appears to be some uncertainty about the exact arsenical strength of the N.S.W. solutions. Mr. Froggatt recommends 1¼ lbs. of arsenite of soda in 16 gallons of water. This is equal to 0.93 per cent. solution of arsenite of soda, and it is not certain whether his solutions have been actually tested by chemical analysis, as have all the Queensland solutions, and the arsenic content determined and calculated as As_2O_3. It appears advisable that each should check the other's formula experimentally in comparison with his own and determine the composition of each by analysis of samples taken just before use.

(c) *Jetting and Dressing with Oil Mixtures.*—Experiments in jetting and dressing with oil mixtures were continued during the year, but the apparently promising results obtained in the earlier experiments were not confirmed by the later experiments on a larger scale. Owing to the presence of the oil the arsenic is not nearly so poisonous to the flies or maggots, and, owing to the agent being present only as an emulsion, the results are apt to be irregular. Definite recommendations as to the use of arsenic and oil mixtures cannot yet be made.

(d) *Dressing with Crude Fuel Oil.*—It was found that ordinary crude fuel oil is a very good dressing for rams' horns, preventing fly attack for a considerable time, and it has proved the most effective dressing of the many which the Committee has tried in the case of extensive lesions where dressings containing poison might be detrimental.

(iv) *Cattle Tick Pest.*—The cattle-tick pest, which annually levies a huge toll on the cattle industry of Australia, has received special attention. Scientific investigations into the life history of the cattle tick in Australia have been undertaken, and important results thus obtained point to a means of effective control by a system of quarantine. Although this work constitutes a big advance, the Institute has neither the necessary administrative powers nor funds to undertake a campaign for the eradication of the tick. A Conference was, however, held in February, 1918, with the New South Wales and Queensland authorities, and recommendations were made to initiate such a campaign. It was estimated that the necessary expenditure during the first two years would be £65,000 and £39,000 respectively. Another matter which is being investigated by the Institute, in co-operation with both the New South Wales and Queensland Departments of Agriculture, is the determination of the composition and strength of cattle-tick dips.

The Special Committee which was appointed by the Institute to report on the matter in 1917 stated that the loss from mortality caused by tick fever is estimated at £7,000,000 for Queensland alone. Considerable loss from this cause occurred also in the Northern Territory and in Western Australia. The decrease in the value of leather production of Queensland owing to this pest amounts to about £114,000 for one year alone. Further, the affected States have suffered considerable direct loss from mortality caused by tick worry, interference with the natural increase of the herds, retardations of growth and improvement of stock, from diminished production of meat, milk, and dairy products.

If over the series of years since the advent of the pest, the collective losses from the varied causes directly attributable to it could be enumerated, they would amount to many millions of pounds.

Apart from the direct losses which have been particularly referred to, the expenditure occasioned in connexion with the erection and maintenance of dipping vats, and general disturbance of stock business, is also very considerable. As the effects of loss to the stock industry ramify through commerce in an extensive manner, the secondary industries also pay their toll to the pest.

Further, the restrictive measures various States have been compelled to put into operation have led to considerable expenditure. For instance the cost to New South Wales alone has amounted during the past fifteen years to £600,000.

Loss is also occasioned to owners of stock within quarantined areas by the application of the restrictive measures imposed, not only in connexion with treatment enforced, but in the interference and curtailment of their business, and deterioration of their herds.

Moreover, the value of land in infested and adjoining areas has depreciated even to 40 per cent. When the extent of acreage involved is considered, this loss alone becomes stupendous.

The above statements give a measure of the economic loss to the Commonwealth from the tick pest. If it could be accurately expressed in figures, the total amount would give a startling indication of its seriousness.

So long as it is allowed to exist, the pest will enforce each year a heavy penalty, to be met not only by the stock-owners, but by all interested in business directly and indirectly dependent upon the cattle industry, as well as by members of the general public in the increased cost of necessary commodities such as meat, milk, butter, &c.

The Special Committee appointed in 1917 made recommendations that further scientific investigations should be carried out (*a*) as to the life-history of the cattle tick, (*b*) on the micro-organism conveyed by the tick and which causes tick fever, (*c*) on the methods of treatment of cattle, and (*d*) on the improvement of tick-destroying agents. As already stated, the Institute has completed certain investigations on the life-history of the tick. A related matter now being investigated by the Institute, in conjunction with the Agricultural Departments of New South Wales and Queensland, is the determination of the composition and strength of cattle-tick dips.

Although the official cattle-dipping formula used in New South Wales and Queensland has hitherto proved efficient and generally satisfactory, it was suggested that the same results might be maintained and certain ill-effects obviated by an alteration of the composition of the active agent. This suggestion is supported by evidence that solutions of lower arsenical content than officially stipulated are effective in the warmer climates, which would indicate that the parasiticide used might possibly be varied with advantage according to the seasons and climatic conditions.

A Committee was appointed in 1920 by the Institute of Science and Industry in conjunction with the Governments of New South Wales and Queensland, to make investigations in conformity with the above suggestions. The members of that Committee are as follows:—

Special Committee on Cattle-tick Dips.

G. E. Bunning, Chairman.
C. J. Booker.
A. H. Cory, M.R.C.V.S., Chief Inspector of Stock, Brisbane.
J. C. Brunnich, F.I.C., Agricultural Chemist, Brisbane.

C. J. Pound, F.R.M.S., Government Bacteriologist, Brisbane.
F. B. Guthrie, F.I.C., F.C.S., Brisbane.
H. Tryon, Government Entomologist, Brisbane.
M. Henry, B.V.Sc., M.R.C.V.S., Chief Inspector of Stock, Sydney.
A. A. Ramsay, F.I.C., Agricultural Chemist, Sydney.
C. J. Sanderson, M.R.C.V.S., Chairman, Tick Board of Control, Lismore, New South Wales.
L. Cohen, Chemist, Tick Board of Control, Casino, New South Wales.
W. C. Carmody, Metropolitan Inspector of Stock, Brisbane, R. Ferguson, Officer in Charge of the Border Cleansing Area, Queensland, and W. Campbell, Oxenford, were added as a sub-committee to assist in the supervision of the investigations.

During the year Mr. S. T. D. Symonds retired from the position of Chief Inspector of Stock for New South Wales, and his successor, Mr. Max Henry, was appointed a member of the Committee in his stead.

Mr. F. B. Guthrie also retired from the position of Agricultural Chemist, New South Wales, and his successor, Mr. A. A. Ramsay, was appointed a member of the Committee. As Mr. Guthrie had removed to Brisbane he was asked to remain on the Committee.

The first experiment took place at Tallebudgera in February, 1921, when it was found that mature female ticks survived after seven days in tests of various arsenical strengths from 5 to 8 lbs. of arsenic (As_2O_3) per 400 gallons of water, with and without emulsions. There was strong evidence that rain which fell during the progress of the experiments prejudiced the results, and the tests could not be considered conclusive.

The experiments were repeated at Oxenford in June, 1921, and briefly, it was found that certain females survived for ten days after dipping and some laid eggs. Larval ticks were found reinfesting the animals on the 3rd day.

From the experimental dipping in 1921 the following facts were established :—

(1) No single treatment with fluids of concentration up to 10 lbs. arsenious oxide per 400 gallons and containing up to five (5) times the prescribed standard proportion of saponified tar, is efficacious in destroying ticks in all stages of development on an infested animal.

(2) The survivors from such treatment are adults and in a stage of development not inconsistent with the hypothesis that they were undergoing the second moult at the time of treatment.

(3) Some survivors lay a full complement of eggs which duly hatch.

(4) A single treatment with arsenical solutions up to full standard strength shows no superiority in destroying all the ticks, over those of half strength and upwards.

In addition, the following tentative conculsions were also arrived at, the correctness of which is still subject to modification in the light of results of experiments since carried out :—

(*a*) Treatment with prescribed standard arsenical fluid affords protection against re-infestation by larval ticks for a period of two (2) days.

(*b*) Heavy rain falling on cattle four (4) hours subsequent to treatment does not diminish the efficacy of such treatment, provided the cattle had dried in the interim.

(*c*) During the second moulting period of the tick's parasitic life, a phase exists in which the tick is resistant to the action of arsenical fluids and the existence of surviving adult females after treatment is apparently due to such phenomenon.

The Committee appointed four of its members—Messrs. H. Tryon (Chairman), C. J. Pound, L. Cohen, and W. C. Carmody, and later Wm. Campbell —as a sub-committee to carry out the following programme :—

(1) Supplementary experiments to ascertain the effect of rainfall at intervals of half-an-hour, one hour, two hours and three hours after treatment with medicament.

(2) To investigate the possibility of transference during their parasitic life of ticks from one beast to another.

(3) To determine whether cattle can be freed from all ticks by means of two applications of diluted medicament, at a diminished interval.

(4) To ascertain whether under the most favorable weather conditions both as to interval between treatment and concentration of medicament, any healthy ticks survive the first treatment, detach, and lay fertile eggs.

The first experiment was commenced in February, 1922. A large number of larval ticks were hatched from fully engorged females, and eight cattle were dipped twice with a fourteen-day-interval and two days later their straw bedding was sown with larval ticks (2,000 to 3,000 each). The cattle were examined by a veterinary surgeon and blood smears were also prepared. The experiment had to be abandoned as the ticks failed to establish themselves.

The procedure was repeated in August with the exception that the larval ticks were placed directly on the animals—about 78,000 being used for each. Again no infestation took place and this experiment was abandoned.

Of the many factors contributing to the failures to secure infestation the following may be cited as the most likely :—

(*a*) The low condition of the cattle which were dry dairy cows that had previously been tick infested.

(*b*) The possible low vitality of the ticks, due to very dry weather when the ticks were hatched.

(*c*) The presence of As. on the skin.

(*a*) *Resistance of Second Moulting Stage.*—The experiments to test the resistance of the second moulting stage were carried out during the first three months of 1923. The animals used were eight cows and two steers, all in good condition and heavily infested, as they had not been sprayed for over three months. They were kept under observation until all mature female ticks had dropped off; then transferred to clean stalls and infested with larval ticks. A week later sprayings were commenced firstly on two cows when the majority of the ticks were undergoing the first moult, and the other animals in pairs (except cow No. 5) at successive intervals of 3, 3, 1, 2, days, thus providing five groups of animals all infested at the same time, and sprayed at intervals of 7, 10, 13, 14 and 16 days respectively after infestation. One animal was kept as a control (unsprayed). The fluid used was Queensland Cattle Dip No. 2 (Homogeneous) at the correct strength (checked by analysis). The animals were examined each day after the spraying, and counts made and conditions noted of the ticks found on the animals and on the ground. The results clearly indicate that the attainment of the second moulting stage has a marked influence in inhibiting the action of standard arsenical dipping fluid.

The other experiments are in progress.

(*b*) *Persistence of Arsenic on Cattle.*—An experiment was made to determine the persistence of arsenic on the skin of the cattle after ordinary dipping.

Twelve (12) days after the usual second dipping a definite area of skin was washed several times, using ½ a gallon of warm water. The washings were then examined for arsenic and 3.5 parts per million were found to be present.

4. **Viticultural Problems.**—In co-operation with the Victorian Department of Agriculture and Associations of irrigators representing New South Wales, Victoria, and South Australia, important investigational work is being carried out by the Institute regarding viticultural problems, including both methods of cultivation and treatment for insect and fungus pests. The Associations recognise the value of Scientific research on viticultural problems, and are contributing up to £1,500 a year towards the cost of the work. The Institute contributed on the basis of 10s. for every £1 expended by the growers. The work is being carried on under the supervision of the Institute and the Mildura Vineyards Protection Board. Experimental work was commenced in the Mildura District in 1919, and an Experimental Station in charge of A. V. Lyon, B.Agr.Sc., has been established at Merbein on land made available

for that purpose by the Victorian State Rivers and Water Supply Commission. This station comprises a number of experimental fields dealing with fertilizer trials, irrigation and cultural problems, and plant selection. A laboratory has been erected and partially equipped.

Interim reports in the form of bulletins have been published in cases when the data obtained warranted such a course. These reports have dealt with the projects mentioned hereunder :—

(*a*) *Manurial Problems.*—The manurial problems were at first confined to trials of phosphatic fertilizers, as the dominant requirement of most of the soils is phosphoric acid. The work has during the last year been extended to include the investigation of the potash and nitrogenous requirements of the soil, for growing grapes, sultanas and currants. The fertilizers being tested are chiefly superphosphate, sulphate of potash, sulphate of ammonia and leguminous cover crops ploughed in. Systematic tests of the effect of these are in progress on old and young sultana and zante currant vines and on young gordo-blanco vines.

(*b*) *Drying of Vine Fruits.*—Research work on the subject of fruit drying has been the basis of a report previously published by the Institute. The report deals with the maturation of the grapes, the Baumé test as a measure of ripeness, and the various factors affecting quality and quantity of the fruit.

(*c*) *Treatment of Vineyard Pests.*—In connexion with fungus diseases the growers have been induced to adopt standardized methods of preparing and applying their spraying solutions, which have been proved by experimental investigation to be those best suited to the conditions and requirements of the industry in the Mildura district.

As the effects of sulphur, used as a dust, bear a direct relation to the fineness of its particles, the bulk of the sulphur used in the district is now bought on the basis of the Chancel test. Previous to this investigational work no guarantee could be obtained with the sulphur then available.

(*d*) *Dried Fruit Pests.*—The life histories of the principal insect pests of dried fruit have been investigated under the conditions of the locality and industry and recommendations for the control of such pests have been issued. The greatest amount of work has been done on the Lesser Dried Fruit Moth or Indian Meal Moth (*Plodia interpunctella*), the most destructive insect attacking dried fruit products. It appears in all buildings in which fruit is stored. The life-history has been worked out and it is found that there are two or three cycles in a year at Mildura. Thus there are moths capable of infesting fruit at any time of the year. The conditions controlling this infestation have been investigated

and methods suggested for its prevention, *e.g.*, the disposal of old fruit, the cleaning of racks and the keeping of nuts, stored grain and grain products under close examination, the complete emptying of the packing houses before bringing in any new fruit each season. As a curative treatment carbon disulphide used at the rate of 1 to 1½ lbs. for each 1,000 cubic feet has been successful against the grubs, and two such treatments at an interval of a week are successful against the moths.

Other work now in progress includes :—

(1) *Resistant Stock Trials* with sultana and zante currants on thirteen varieties of resistant stocks and a test of the bearing properties of sultanas on their own roots as compared with sultanas on two varieties of resistant stock. Trials of zante currants have been commenced to test the influence of spacing on average yields.

(2) *Soil Studies* have been extended to determine the underground water-profile from an irrigation furrow on a loam soil, and the study of the injurious salts of alkali soils has been commenced.

In connection with the viticultural investigations, one of the most valuable results has been the readiness of the growers to adopt the recommendations when issued. As a consequence, substantial improvements in viticultural practice have followed, particularly with respect to :—

(i) The use of systematic, suitable and adequate dressings of fertilizers.

(ii) The general adoption of preventive treatments for insect pests and fungus diseases.

(iii) The general adoption of special precautions to preserve the quality of the fruit in the drying season.

(iv) The general adoption of the Baumé test as a measure of ripeness for picking.

(v) The control of the most serious dried fruit insect pest (*Plodia interpunctella*).

There is an increasing demand for instructive literature dealing with viticulture, not only from the local growers, but also from all the States, and especially from other irrigation settlements. Mr. Lyon has prepared a comprehensive bulletin which deals in a practical way with such subjects as the following :—

The Establishment of a Vineyard, Pruning and Training of the Vine, Irrigation, Agricultural Drainage, Manurial Problems, Fruit Drying, Spring, Summer and Routine Work in the Vineyard, Fungus Diseases and their treatment, Insect Pests and their control, Review of Problems in the Viticultural Industry.

This bulletin will be No. 27 of the series published by the Institute and should be available for distribution at an early date.

5. Seed Improvement.—The work of the Seed Improvement Committee for the year 1922–23 was confined to the revision and completion of the work on wheat, and culminated in the publication of Bulletin 26 (A Classification and Detailed Description of the More Important Wheats of Australia) which is a revision and extension of Bulletin 18 (A Classification and Detailed Description of Some of the Wheats of Australia).

Since the publication of Bulletin 18, Professor J. Percival's comprehensive book "The Wheat Plant" (London, 1921) has appeared. It has been found advisable to adopt his botanical classification of the species of wheat, as it is more simple and satisfactory than Hackel's, which was the most generally accepted prior to the publication of Professor Percival's book.

Since most of our Australian varieties belong to the one species it is necessary to study all possible points of distinction within the species. A description is given of these points showing the classes and types which may be found among the bread-wheats of the Commonwealth.

In co-operation with the State Agricultural Departments experiments were conducted in order to obtain some idea of the variations to be expected with change of environment. Seed-wheat of a number of varieties, taken in each case from a single plant of reliable pedigree, was sent to an experiment farm in each State. Arrangements were made for sowing, and for field officers to take careful observations of the plants from the day they appeared above ground to the day of harvesting. The temperature, rainfall and character of the soil on each farm were taken into account. The experiments indicated that agricultural characters such as height of plant and quantity of foliage appear to be too variable for any reliance to be placed on them in questions of identification.

The bulletin concludes with a detailed description of eighty-six of the more important wheat varieties. These descriptions include a brief account of the origin of each variety giving the pedigree and the name of the person responsible for its introduction. The type of country for which the variety is best suited has been indicated whenever sufficient information could be obtained to enable this to be done. The publication of this bulletin completes the present work of the Seed Improvement Committee. All the more important varieties of the three principal cereals, wheat, oats, and barley have now been described and classified, and these descriptions and classifications have been published in the Institute's bulletins. In order that the work already accomplished may be readily utilised and may be kept up-to-date, it will be necessary to publish from time to time descriptions of any new varieties of wheat, oats and barley, that may prove their worth.

The Chairman of the Committee for the year has been A. E. V. Richardson, Esq., M.A., B.Sc., Superintendent of Agriculture for Victoria, and except for the addition of R. T. Patton, Esq., B.Sc., lecturer in Agricultural Botany at the University of Melbourne, the *personnel*, referred to in the previous report, has remained unchanged.

The work on wheat, oats, and barley, referred to above, having been brought to a successful conclusion, the Committee were unanimous in the opinion that similar work on the varieties of potatoes should be undertaken. They recommended that a special sub-committee should be appointed and should include the potato experts of the three States most concerned, namely, New South Wales, Victoria, and Tasmania. The sub-committee would work with the Secretary and Investigator of the Seed Improvement Committee on the classification and nomenclature of potato-varieties. This proposal was agreed to and the sub-committee was formed. The State Departments signified their willingness to cordially co-operate and they allowed their departmental officers to act on the Committee.

The Committee formed consisted of A. J. Pinn, Potato Expert, Department of Agriculture, New South Wales; C. E. W. Oldaker, Superintendent of Agriculture, Tasmania; J. T. Ramsay, Potato Expert, Department of Agriculture, Victoria; R. T. Patton, B.Sc., Botanical Department, University, and G. Seymour, of Melbourne, author of "Potato Growing in Australia."

Two meetings were held, a scheme of procedure outlined, and submitted for approval. Accurate descriptions of varieties of potatoes cannot be compiled even in part from dried specimens as is possible with cereals. All varieties would have to be grown and close observations made over the growing period. For the work to be efficient, it was decided that it would be necessary to have two experimental plots in each of the three States in which all the varieties would be grown. This would make it possible for the effects of soil and temperature to be fully allowed for.

Notwithstanding the co-operation cordially offered by the State Departments the expenditure necessary on labour, rent of land, and travelling to and from the various plots was found to be greater than the funds available to the Institute could bear, and the work had to be postponed until necessary funds are made available.

6. The Prickly Pear Pest.—Prickly-pear in Australia is estimated to cover an area of about 25 million acres, which is greater than the total area of cultivated land in the Commonwealth, which was never more than 18,500,000 acres. It has been estimated that this pear infested area is increasing at the rate of about 1,000,000 acres annually.

In November, 1916, the Institute submitted to the Commonwealth Government a scheme of investigation with a view to the eradication of the pest. This scheme was ultimately approved by the Commonwealth, New South Wales and Queensland Governments, and came into force on the 1st June, 1920. It provides as follows:—

(*a*) That investigations should be carried out as to the suitability of insects and fungi, known to be inimical to prickly pear, for acclimatisation in Australia, as to the method of action of such insects or fungi on the pear, and as to such other matters as may arise in connexion with any biological or chemical researches found necessary.

(*b*) That the work should be placed under the authority of a biological expert, who shall be responsible to the Executive Committee of the Advisory Council of Science and Industry, and who should receive a salary of £1,200.

(*c*) That three laboratories, comprising one central laboratory and two subsidiary laboratories, should be established and maintained in Queensland and New South Wales.

(*d*) That the central laboratory should be established at Brisbane where the insects would be received immediately they reached Australia, and where the staff would have access to literature and facilities for the use for special investigations of University and Government laboratories.

(*e*) That the two subsidiary laboratories should be established in country infected with prickly pear. One of these should be in New South Wales, whilst, for the other, the Queensland Government's offer of the Dulacca Experiment Station should be accepted. These stations would carry out the work of breeding and testing the introduced insects, and should be in charge of thoroughly qualified entomologists, at salaries of £750 per annum.

(*f*) That field laboratories should be established, at such places and at such times as may be deemed necessary by the biologist in charge, for the purpose of introducing such insects as are found suitable into particular areas, or for other special purposes.

(*g*) That the sum of £8,000 per annum for a period of five years should be made available for this work, of which sum £4,000 should be contributed by the Commonwealth Government and £2,000 each by the Governments of New South Wales and Queensland.

Instead of the Executive Committee of the Advisory Council of Science and Industry exercising the responsibility referred to in (*b*) above, the expenditure of the money and, in general, the business side of the investigations has been carried out by a Commonwealth Prickly Pear Board appointed for that purpose and has held nine meetings. It now consists of the following:—

COMMONWEALTH PRICKLY PEAR BOARD.

Sir George H. KNIBBS, the Director of the Institute of Science and Industry, representing the Commonwealth (Gerald Lightfoot, M.A., represented the Commonwealth before the Director's appointment), Chairman.

A. G. MELVILLE, Under-Secretary, Department of Lands, Brisbane, representing Queensland.

G. VALDER, Under-Secretary and Director, Department of Agriculture, Sydney, representing New South Wales.

The officer in charge of the Board's work is J. C. Hamlin, M.Sc., at present in the United States of America. W. B. Alexander, M.A., is Acting Officer-in-charge in Australia.

The investigations which aim at the possible control of prickly-pear by biological means were continued during the year 1922-23, and a number of consignments of insects, collected and bred by officers employed in the United States of America, especially in Texas and Florida, have been received during the year. The introduction and acclimatisation of the cactus enemies, viz., insects and disease-producing micro-organisms into Australia has been successful. A very large number of insects is now held in captivity at the Board's laboratories at Sherwood, Westwood, Chinchilla in Queensland and at Biniguy in New South Wales.

The majority of the imported insects have been tested against a large number of economic plants both in America and in Australia and in no case did the species survive on plants other then cactus.

The work in connexion with the prickly-pear diseases, in view of its minor importance as compared with the destructiveness of the cactus insects, has been suspended for the time being in order to enable the staff to deal more efficiently with the enormous increase in the number of insects at the Board's laboratories.

Amongst the insects introduced, the most destructive to those prickly-pears which have been naturalized in this continent, have been the Cochineal insects (*Dactylopius tomentosus*—three strains), the moth-borers (*Melitara*) from Texas and Florida, and the *Mimorista* moth from Texas.

The Cochineal insect (*Dactylopius tomentosus*) is of primary importance, being very destructive to the two worst pests of Queensland and New South Wales, viz., *Opuntia inermis and Opuntia stricta.*

The moth-borers feed in their larval stage on the internal parts of the plant and destroy the attacked part, especially in humid weather.

Other insects of importance which have been imported are certain cactus bugs (several species of *Chelinidea*) beetles (*Moneilema*) scavenging flies which destroy prickly-pear damaged by other insects or by disease producing organisms, and Cochineal insects. In addition to these various other insects (chiefly beetles and plant-bugs) have been introduced, but their effects, as observed in Australia; have been of so little value from the point of view of prickly-pear control, that they are not now receiving special attention. Certain other insects (moths and midges) are being imported, but as yet they have not become established in the laboratories.

In view of the results obtained with economic plants, the Governments of New South Wales and Queensland have agreed to a scheme formulated by the Prickly-pear Board for the liberation of Cochineal (*Dactylopius tomentosus*) in certain densely infected areas in New South Wales and Queensland. This work commenced in February, 1924.

As soon as the necessary tests have been completed to ascertain that other species of insects will not attack plants of economic value, steps will be taken by the Board to liberate them, in co-operation with the Governments of New South Wales and Queensland. At present it is impracticable to forecast

definitely the probable result of the liberation of the insects, but the indications are that, provided the insects are as effective in the field as they have been shown to be when under control at the Board's laboratories, the complete control of the prickly-pear may ultimately be brought about.

7. Timber Borers.—During the last few years the damage caused by various wood-boring insects, has produced a considerable amount of alarm, amounting almost to a scare. Timber imported from the Pacific Islands, East Indian Islands and Asia has been reported to have been seriously infested with boring insects, some of which have been reported as new. Investigations by certain Commissions that have been concerned with house building on a community basis, have disclosed the fact that borer-infested houses are considerably more numerous than was suspected. The methods that have given the best results in treating borer-infested timber in houses have proved to be troublesome, uncertain, costly and dangerous. A considerable amount of timber is imported into Australia and the assistance of the Institute was sought with regard to investigations on the characteristics of the borers attacking it and the best methods of treatment of infested timbers.

A study of the literature available indicates that there is little evidence based on reliable experiments to indicate how timber already attacked should be treated, how sound timber can best be protected from attack, and how the various borers and their methods of attack can respectively be determined.

Very little is known about the period of time timbers remain infested or under what conditions they are liable to attack. The resistance of the borers to disinfectants and gases, moist or dry heat, &c., are practically unknown.

Thus, there is scope for considerable investigation along these lines, *i.e.*, the treatment of infested timber and the prevention of infestation. But investigations should aim also at preventing infestation in the forests, by attacking the insects themselves, and in the case of imported timbers at determining how and where they should be treated, and under what conditions they should be allowed entry into the Commonwealth.

Ever since the war, the Quarantine Department has given special consideration to the possible danger of injurious timber-boring insects being in introduced in the logs and sawn timber imported from the Pacific Islands, the Dutch Netherlands, the Philippines, Eastern Asia and America, and in 1922 a proclamation was issued declaring all wood-boring beetles to be noxious insects and their introduction to be prohibited. The same subject was also considered by the Commonwealth Board of Trade, which submitted the matter to the Institute for report in August, 1922.

At the Inter-State Premiers' Conference held in May, 1923, the Acting Premier of New South Wales suggested that the question should be taken up as a Federal matter and he offered to co-operate with the Commonwealth in investigating the problem.

The subject was also included in a proposal for new investigations submitted by the Institute to the Commonwealth Government in April, 1922, in connexion with the Estimates for 1922–23, but the Institute was subsequently informed that funds for the work could not be provided.

B. Forest and Vegetable Products.

1. General.—The vegetation of Australia possesses quite special characters, a great number of the commonest and most widely distributed trees and plants of the continent being quite distinct from those of other countries. To this fact is due the unique properties of some of our forest products. Even our timbers have properties quite unlike those of other lands and on the chemical side, it is sufficient to mention the many varieties of eucalyptus oil to show how markedly Australian essential oils differ from those of other countries. A consideration of these facts disclose how desirable it is for Australia to initiate a scientific investigation concerning the character of her forest products. In the past too little of such work has been carried out.

2. Paper-Pulp Investigations.—(*a*) *Chemical Pulp from Eucalypts.*—During the period under review the semi-commercial pulping and papermaking tests, in progress at Geelong when the Director's previous report went to press, have been completed. The results proved beyond doubt that the most abundant species of eucalyptus can be easily pulped by a modification of the soda process, and the experiments in the paper mill showed that such pulp could be used advantageously in the manufacture of a fairly wide range of papers.

The cost of production of the pulp was worked out from the data obtained in the pulping plant and the conclusion reached was that there should be no difficulty in manufacturing chemical pulp in a number of localities at a cost not greater than that of imported pulp of equivalent grade. Furthermore, the indications were that in some favoured parts of the Commonwealth, notably in Tasmania, and possibly also in Victoria, chemical pulp could be readily produced at a cost that would bear competition with imported mechanical pulp.

(*b*) *Newsprint.*—The Institute has directed particular attention to the possibility of producing cheap chemical pulp because if this can be accomplished the way would be open for manufacturing newsprint in Australia on a scale commensurate with the demand, and at a satisfactorily low price. Investigations recently undertaken in conjunction with the Forestry authorities of the various States, and others interested in the establishment of the newsprint industry, have for their object the determination of the cost at which this class of pulp could be made, and the conditions under which the industry might be established. It is believed that important and far-reaching results will accrue from this inquiry.

(*c*) *Chemical Pulp from Pines.*—In addition to the work on the pulping and papermaking qualities of various eucalypts, the pulping of pines has been extensively investigated in the laboratory. Considerable importance is attached to this branch of the work, because of the need for a certain amount of long-fibred pulp in the manufacture of most kinds of paper, including newsprint. Abroad, such long-fibred pulp is made from spruce, but the growing of spruce for pulpwood in Australia is recognised by competent forest authorities to be economically out of the question. Therefore, in the event of the

establishment of the newsprint industry, this long-fibred pulp would at first have to be imported, but, if it were possible to produce a suitable pulp from locally grown pine at a satisfactory price, the industry could be made self-supporting in little more than a decade. Hence, importance is attached to research on the utilization of the pines. Valuable results have already been obtained and the practical details of a method for obtaining a high yield of comparatively easily bleaching pulp are now being worked out.

(*d*) *Mechanical Pulp.*—Up to the present time no systematic investigation of the possibilities of making mechanical pulp from local woods has been attempted either here or abroad. In view of the economic importance of being able to use even a small proportion of mechanical pulp in the manufacture of newsprint locally, plans have been made for an investigation of the grinding properties of certain young white-wood eucalypts.

(*e*) *Publication of Results of Investigations.*—During the period under review a report on the results of the investigations was published as Bulletin No. 25 of the Institute. Printed on paper made during the investigations, this publication has been favourably commented on abroad as well as in Australia. As a result of the Institute's investigations the establishment of the pulping industry in Australia appears to be within measurable distance of realization.

3. Tannin Survey.—Work in connexion with this survey has been continued at the Institute's Perth Laboratory. A summary of the work done is :—

(*a*) *New South Wales.*—A total of 217 samples has been examined of which 142 samples are barks, 46 wood (sawdust) and 29 kino. While few of the barks are comparatively high in tannin, (*e.g.*, *Acacia decora*, *E. paniculata*, *E. sideroxylon*, and *E. smithii* are all over 20 per cent.), the majority of them are low. In addition many of them impart an objectionable red colour to leather. On the other hand a selection could be made of barks and of woods suitable for the manufacture of a tannin extract. The wood of *E. bosistoama* averages about 10 per cent. tannin and other varieties contain between 6 and 10 per cent. Usually the wood-extracts are not highly coloured and some of them compare favourably in respect of tannin content with such well known materials as chestnut, oakwood, &c. A few of the kino samples are remarkably high in tannin, are readily soluble in water and furnish suitably coloured liquors.

The work of the survey shows that the question of making tannin extracts on an experimental scale is worthy of further consideration.

(*b*) *Tasmania.*—A total of 33 samples has been examined of which 24 are barks and nine wood (sawdust). With the exception of the " wattles " (commercial kinds) the majority of the samples submitted are too low in tannin content to be of commercial value.

(*c*) *Western Australia.*—In addition to the work previously done in connexion with the Western Australia Tannin Survey, a further total of 61 samples has been examined. Much of the work has been reported in the Institute's Circular No. 8, published in August, 1922. The results show that in addition to the well-known " mallets " there are many other useful tanning materials in this State.

In summarizing the results of the examination of 75 different species of Western Australian barks it can be stated that 20 per cent. of them each contain 20 per cent. of tannin or over, 12 per cent. of them contain 15 to 20 per cent. of tannin, 22 per cent. of them contain 10 to 15 per cent. of tannin and the remainder contain less than 10 per cent.

It has been demonstrated that many barks and woods suitable for tannin-extract manufacture exist in this State.

(*d*) *Queensland.*—A total of 116 samples has been received to date. A few have been analyzed and work on the remainder is in progress.

(*e*) *Papua.*—A number of barks from this Territory was examined and found to be typical mangroves. All these gave extracts which imparted an objectionable colour to the pelts. There are doubtless other varieties of trees in Papua possessing valuable tannin contents, but it has been decided to defer their investigation until the botanic classification of the various trees and the extent of their occurrence has been ascertained.

4. Mangrove Decolourization.—During the past year the Perth Laboratory also carried out investigational work in connexion with this problem. The mangrove is a tree growing in considerable quantities in the north-west of Western Australia and in still greater quantities in the northern parts of Queensland. Certain varieties also grow in Papua. Although the bark contains a high content of tannin, its present use in Australia for tanning purposes is negligible owing to the objectionable red colour it imparts to leather tanned by liquors produced from it. During the year, attempts were made to decolourize both the liquors and also concentrated extracts by means of the process devised by this Institute for treatment of Marri-kino, which also imparts a red colour to leather. These attempts, however, were not successful ; the problem is being further investigated, attempts at decolourization being made by the use of various metallic salts, chiefly those of aluminium. The problem is, however, a complicated one.

5. Physical Properties of Australian Timbers.—There is still much to be done in acquiring a complete knowledge of the physical properties of Australian timbers. In many cases it is impossible to decide which is the most suitable timber for a particular industrial application. There is for instance, much to be learnt concerning such properties of Australian woods as the following :— elasticity, pliability, strength, resistance to impact, hardness, workability,

affinity for water, shrinkage and its relation to the moisture content, effect of moisture content on strength, liability to rot, inflammability, &c. Compared with those of several other countries and particularly with those of America, the Australian manufacturer is at a disadvantage. Several of them have approached the Institute with requests that something be done to alter the present state of affairs, *e.g.*, the Adelaide Congress (1922) of the Carriage, Waggon and Motor Builders' Association, who carried a motion to that effect. This question of the mechanical properties and the timber physics of Australian wood, has been long realized by the Institute to be a problem of outstanding industrial importance, and one which should be regarded as urgent.

In regard to the properties of timber, the well-equipped United States Forest Products Laboratory has evolved certain standard methods of investigation and these demand the use of certain standard machines. These have been adopted by Canada and by India. As is well known the U.S. Laboratory is a large organization—during the war its *personnel* was about 450 and its yearly appropriation £140,000—and it has produced a large volume of results. Owing to this it is desirable that tests of Australian timbers should be strictly comparable to these as well as to those of the other countries mentioned. It would then be possible to apply to our timbers many deductions that have relation to foreign timbers. The most economical means of arriving at suitable comparative results is by the adoption of the American standards. And in regard to Australia it is obvious that (*a*) from the point of view of economy, and (*b*) in order to obtain comparable results throughout every State, it is preferable to carry out the work by some Federal organization. With that end in view this Institute has been endeavouring to initiate such work and has recently communicated with the State Forestry Departments to ascertain whether they desire to co-operate in the work in accordance with the resolutions passed by the last Premiers' Conference (*see* Section IV. of this Report).

Various mechanical tests of timber have been carried out from time to time by several Universities and other authorities in Australia. Often, however, this work is not comparable as between State and State and in many cases is not in accord with American practice. In addition its objective is often limited and the work is intended to serve only a limited section of timber users. While such work is of course useful, it is easily seen that from a national point of view it is not entirely satisfactory.

6. Miscellaneous.—Certain miscellaneous investigations have been also carried out at the Perth Laboratory. A series of leather samples tanned by selected Australian tanning materials has been prepared. About 30 different varieties of materials, both bark and leather, will be exhibited at the forthcoming British Empire Exhibition. In addition, a number of miscellaneous experiments have been carried out on various matters, such as the solubility of a sandal-wood oil, the influence of surface tension and surface action of various liquors used in the tanning of sheep-skins, banksia fibre, &c.

C. Manufacturing Industries.

1. Fuel Research.—*Australia's Liquid Fuel Problem.*—The ever-increasing demand for power and for liquid fuels for use in automobiles has caused a fuel problem to arise in every civilized country. Owing to the varying nature of their national resources this problem has assumed different aspects in different parts of the world, and thus, in general, each country has to work out its own fuel technology. In Great Britain, where there is an urgent need for a more economical use of coal, the problem is being studied by a governmental National Fuel Research Board. This body is specializing on the question of low temperature distillation of coal, which process promises to give a smokeless solid fuel as well as an adequate supply of liquid fuels for the all-important internal combustion engines. Germany till quite recently was dependent upon other countries for the supply of her very necessary liquid fuels. This unsatisfactory position—positively dangerous in times of war—has been overcome by scientific research. She has developed a new national liquid fuel composed of benzol, alcohol, and tetralin. The latter is formed by hydrogenating naphthalene, the greater proportion of which was considered in former years to be a waste product. France is in the same position as Germany was, and is keenly alive to the danger. She has recently adopted by law a national liquid fuel to be composed of mixtures of alcohol and petrol. She has also recently initiated an Institute of Scientific Research in order to study such national problems. Canada, poorly supplied with black coal, is concentrating on the question of brown coal, of which she has enormous quantities. For some years the problem has been energetically studied under the co-ordination of the Dominion Fuel Board. The need in Canada is for a solid fuel to replace American anthracite. America, though plentifully endowed with solid and liquid fuel, has realized that dependence for the latter on well petroleum is not safe, and so steps are now being taken to exploit her immense deposits of oil-shale.

Turning to Australia, on the one hand we have no national fuel authority in existence, and on the other an outstanding problem in the utter dependence on overseas sources of supply of liquid fuels. In a land of such long distances the importance of these latter scarcely needs emphasizing.

The Director of the U.S. Bureau of Mines wrote in 1920 :—" All the statistics available to me dealing with crude oil-production and consumption . . . . . lead to the conclusion that it is only a matter of a few years under existing conditions until there must be developed other sources of hydro-carbon oils than the oil-wells themselves. These sources are limited to high volatile coals, cannel coals, lignites, and oil-shales." This opinion may be taken as representative of the considered judgment of every unbiassed authority on the future of oil supply.

Surely, then, the time is ripe for national consideration in Australia of means whereby motor-spirit and oils may be obtained from coal and shale, not only to meet the vital needs of defence, but also as an insurance against the time when shortage in petroleum production will curtail imports in the quantities required for satisfaction of ordinary needs.

The importance of starting work in this direction would not be diminished if natural petroleum were discovered in Australia to-morrow, for future oil demands are certain to exceed production from all sources whatever, and, besides, several years must be devoted to investigation and development before any material output of oil could be developed from coal or shale. How then may oil-production from such sources be stimulated ?

In the case of shale, one method has already been tried without much success, viz., a Commonwealth subsidy on each gallon of crude oil produced. This failure would seem to indicate that oil-production cannot be left entirely to private initiative ; and if that is so for shale, where oil is the sole or main product of manufacture, it would be likely to be more true of coal, where the coke, gas, and ammonia simultaneously produced with motor spirit and tar oils have a fuel and money value together greatly exceeding the oil product.

Two considerations should be borne in mind in connexion with the economic possibilities of oil recovery from bituminous materials :—

(1) It is demonstrable that the oil potentially obtainable by known methods from the coal, lignite, and oil-shale deposits of the world is many hundreds—probably thousands—of times greater than the whole estimated reserve of natural petroleum.

(2) With the exception of benzol and tar oils recovered as by-products of the metallurgical coke and coal-gas industries, which together make a welcome but relatively small addition to liquid fuel supplies, the only established industries in the world with any considerable output of oil from shale and coal are the Scottish shale companies and the brown coal tar companies of Germany, the joint production of which amount to only a few hundred thousand tons of oil.

Whilst such facts enjoin caution they need not hinder faith in the future utilization of such materials for oil-production on an immensely extended scale. Research, both scientific and technical, has been very active during the past decade. The war, especially emphasizing the meaning of " oil " to the modern world, called forth efforts which are only now beginning to mature. The first thing to be done if Australia is minded to examine her possibilities of oil-production from bituminous materials, is to set up a permanent organization for the purpose, composed of men of repute and special knowledge.

An essential preliminary to further action is to ascertain the existing state of knowledge of the subject and the stage of development which has been reached in other countries. The Institute published a Bulletin (No. 24) last year on " The Production of Liquid Fuels from Oil Shale and Coal in Australia," which makes such a review, together with a summary of Australian resources of raw material. The next step is to establish a Fuel Research Laboratory to carry out the systematic investigation of selected raw materials and of processes likely to yield successful results under Australian conditions.

Some years ago a representative and influential Committee to consider Fuel Research was called together by the Institute of Science and Industry, but was obliged to disband for lack of funds. It may be hoped that with

fuller knowledge of the important issues at stake, the Commonwealth Government will reconstitute a similar body with the intention of creating a permanent Fuel Research Branch of this Institute and will endow it with sufficient funds for effective work. This is the more necessary since, as has been pointed out already, there can be small hope of private enterprise undertaking the expensive investigation called for on behalf of potential oil-industries.

The case for Commonwealth support for fuel research, with special reference to motor-spirit and oil-production from coal and oil-shale, rests on its responsibility for defence, the absence to date of proved petroleum pools in Australia, the accumulating evidence of the early inadequacy of supplies from wells to world demands, the fact that the States have not made adequate provision for fuel research, the inability of some States possessing suitable raw materials, *e.g.*, Tasmania, to face the expenditure required, and the obvious economy of a central organization for achieving a national purpose, and the fact that the necessary investigations could be carried out much more effectively at a central and well-equipped laboratory.

Lord Salisbury told the recent Empire Economic Conference that the business of research was an essential element in industrial progress, and the problem of the production of liquid fuels was specially mentioned as one in which co-operative investigation of the Dominions with Great Britain was much to be desired. It may be hoped that all who appreciate the importance of the issues here raised will do what they can to get Australia started on the path of fuel research already taken by all progressive nations.

2. Carburettors and Liquid Fuels.—During the year investigational work on a special type of carburettor, undertaken in co-operation with the Defence Department and the Navy Office, was completed. The results of the tests indicated that the attachment of the carburettor to an internal combustion engine led to an increase of efficiency as compared with certain standard carburettors, and at the same time it was well suited for the efficient carburetion of a wide range of fuels. At the conclusion of the tests it was considered that a stage had been reached at which it was desirable that further work be carried out by commercial interests with a view to the economic exploitation of the invention.

During the course of the work the behaviour of various fuels such as various grades of petrol, benzol, alcohol and varieties of oil distilled from coal was examined. In addition, a specially Australian product—eucalyptus oil—was investigated. As a motor-fuel this material is quite satisfactory, either used alone or when used in mixtures. It does not, however, contain a sufficient proportion of a substance volatile enough to render starting easy. The oils are generally fairly viscous, and thus, notwithstanding their relatively high calorific power, they require a fairly large jet opening. With regard to "knocking," all the eucalyptus oils studied allowed of a greater spark advance than did the petrols.

Whilst the results of the engine tests made by the Institute on eucalyptus oil were satisfactory, the difficulties in obtaining anything like adequate supplies of the oil, even in times of national emergency, would be a matter of great difficulty.

3. Pottery.—The investigation of various Australian deposits of clays and kaolins with a view to their use in the manufacture of white earthenware or high class pottery was continued during the period under review.

Field work of a limited character did not reveal any kaolin or other clay deposits of better grade or possibilities than those previously examined. Experimental work on samples obtained from a Lal Lal kaolin deposit by boring, indicates definitely that the surface portions of the deposit contain more colour-forming compounds of iron and titanium than the deeper portions, and that these contaminated surface portions are not a satisfactory source of china clay for white wares. The limitations and the possibilities of the two purification processes mentioned in last year's report have been more clearly defined. Their application to a number of china and plastic clays has permitted a more complete relative grading of the values of these clays. Without the application of one or other of these processes the prospect of using the primary granitic kaolins commercially for the manufacture of white wares are not good.

A 15-cwt. sample of kaolin was despatched to the Osmosis Company Limited, London, for a test on a medium sized machine in the company's research station. The information thus obtained has given indications as to the nature of the machinery required, and the costs of operating such a process on a large scale. Further medium scale experiments require to be done in connexion with the other process—elutriation—in order to reach a decision as to which of the two processes is the most satisfactory when considered from all aspects. Arrangements are being made to carry out these experiments at the Institute's Laboratory at Brunswick, at which place arrangements are also being made to investigate further clay samples from other States, and also such samples as may be submitted by owners of clay deposits or by other bodies desirous of having clay tests carried out.

During the year processes have been developed by means of which other difficulties experienced while firing earthenware bodies have been overcome. The colour of the wares was also further improved, and in the porcelain type a high translucency was developed. A difficulty experienced with this type of ware through loss of shape during firing was overcome by the use of suitable supports, and further knowledge has been obtained concerning the need for careful and definite control of the oxidizing and reducing properties of the atmosphere during the final stages of firing, especially in the case of porcelain. Any variation of these conditions of the atmosphere has a very marked effect on the colour of this type of ware. It has, however, been demonstrated that with proper control of firing conditions the purified Australian china-clays so far studied will yield a range of wares equal in colour and translucency to good imported wares. Further, work requires to be done in connexion with the purification of such clays, but in this connexion a fairly wide range of

analyses indicates that the colour-forming ingredients in bodies deriving their clay contents from Australian purified china-clay obtained from at least ten feet below the surface of the deposit are not present in much greater amounts, and sometimes less, than in bodies which give satisfaction in other countries.

The behaviour of the glazes in use has also been further investigated, and formulæ have been developed giving glazes which withstand severe "crazing" tests.

4. Paints, Enamels and Varnishes.—In order that standardization might be secured between the various railway authorities in Australia in respect of specifications for the purchase of paint supplies, varnishes, &c., and that the relative merits of enamelling as compared with painting and varnishing might be tried out by experiment, a Committee, consisting of Chemists and Research Engineers of the New South Wales, Victorian, and Western Australian Government Railways, was appointed by the Australian Railways Commissioners in 1921. In their report the members of this Committee recommended, *inter alia*, that the Institute of Science and Industry should be approached with a view to the initiation of a comprehensive investigation into the question of "mixed paints and the painting of buildings." This recommendation was accordingly forwarded to the Institute towards the end of 1922.

The Institute has also received a number of inquiries for information on various problems in the paint industry, and there is no doubt that investigations on these matters should form an important branch of its activities. In this connexion it should be noted that such work comes exactly within the functions which the Institute was established by Parliament to perform. The Institute's Act expressly provides that the powers and functions of the Director shall include :—

> "The testing and standardization of scientific apparatus and instruments and of apparatus, machinery, materials and instruments used in industry."

In 1921–22 the total value of the production of the paint and varnish factories of the Commonwealth was £1,347,000, and, in addition, imports of such materials were valued at £426,000. The industry is, therefore, of considerable magnitude.

A recommendation was accordingly made to the Minister asking for a sum of £600 with which to carry out the investigation. This recommendation was, however, not approved. In June, 1923, the matter was again brought up, and funds were asked for on the estimates for the year 1923–24. The necessary funds were not made available, and the project has, therefore, lapsed for the time being.

5. Refrigeration and Cold Storage Problems.—Towards the latter part of 1922, the Victorian Institute of Refrigerating Engineers, after lengthy consideration, put forward a proposal to the Minister of Trade and Customs, urging the Commonwealth Government to establish a Refrigerating Research Station where all the difficult problems peculiar to Australia in connexion with the export of every kind of perishable produce could be studied

and where proper standards of treatment could be established. It was believed that, by the knowledge thus gained, it would be possible to land on the British markets Australian meat, butter, fruits, &c., in such condition that much better prices would be realized, and, incidentally, the revenue of the Commonwealth would be largely increased. It was also pointed out that the magnitude of the industry concerned was large, as the export trade of refrigerated Australian produce amounts to no less than £16,000,000 per annum.

These proposals were considered by the Australian National Research Council, and at one of their meetings the following resolutions were carried :—

1. " That the Australian National Research Council is of the opinion that research work in Australia in respect to refrigeration is urgently needed and is a matter of vital importance to the Commonwealth."
2. " That a letter be sent to the Prime Minister asking him to convey to the Institute of Science and Industry the desire of the Council to co-operate in any action that may be decided upon with a view to furthering the object of Australian research in connexion with refrigeration."

The Institute accordingly recommended in September, 1922, that a sum of £1,500 be granted in order to initiate the work. This recommendation, however, was not approved. The matter was again brought up in the early part of 1923, and in the draft Estimates submitted for the year 1923–24 a sum of £2,000 was included for refrigeration research. No money was, however, made available for the purpose.

While the above negotiations were taking place, the Australian National Research Council appointed a representative Committee in Melbourne to carry out experiments to ascertain whether any improvements are practicable in present methods of freezing and thawing of beef, especially with a view to eliminating " drip " from the meat when thawed. This Committee is co-operating with the British Food Research Board, which has succeeded in obtaining perfect preservation of *small* pieces of beef. The Committee is carrying on its work in co-operation with various organizations, *e.g.*, the State Government Cool Stores, Melbourne, has promised valuable facilities of a varied nature, meat exporting firms have undertaken to provide the beef without charge, and the necessary special instruments will be lent by the Melbourne University. The Minister has also approved of a grant of £200 from this Institute's funds.

6. Metallurgy.—The immediate need for research into Australian problems connected with the mining and treatment of common metals such as lead, zinc, copper, &c., does not appear to be so great as in the case of other primary industries. This is mainly due to the fact that a large proportion of the Australian production of these metals is in the hands of comparatively large and well organized companies who are able to maintain their own research laboratories and staffs of qualified chemists and metallurgists.

A totally different state of affairs exists, however, not only in the case of the less common metals, but also in the case of a large number of common economic minerals such as ochre, barytes, magnesite, mica, asbestos, &c. Comprehensive information regarding deposits of these minerals, their methods of treatment, &c., is not readily available in convenient form. Details of particular deposits are available in the publications of the various State Geological Survey Departments, but, in general, these publications contain little information concerning the chemistry of manufacture of the various minerals, the purposes for which they are used, and the markets available. Such information is, however, already to a large extent in the possession of chemists and technologists in the several States. Again, accurate information regarding markets and their potential needs for all products capable of manufacture from the minerals under discussion is available in other quarters. Further, the important information concerning the state of knowledge in other countries of a particular mineral is only obtainable by a wide and intensive expert examination of periodical literature, scientific journals, &c.

For the establishment on a stable basis of such industries, it is important that a central body should co-operate with the various State authorities, industrial organizations, and experts, chiefly as a collector of information concerning deposits and their extent, composition, &c., but also to co-ordinate research and, where necessary, to carry out further investigation.

The foregoing was submitted to the 1923 Premiers' Conference when a suggestion was made that the Institute should co-operate with the States along the lines then indicated. Efforts are now being made to evolve a scheme whereby the suggested work may be initiated.

D. Bureau of Information.

An important part of the Institute's activities is the work carried out by the Bureau of Information. This Bureau is furnished with a library of scientific and technical books and is also in regular receipt of a varied selection of periodical literature, some of which is of a technological and industrial nature and some of which concerns only pure science. These journals are received from a large number of countries, both British and foreign, and many of them are taken by no other Australian individual or institution. The importance of having such journals regularly perused cannot be over emphasised, as in many cases it is thus possible to amplify the knowledge of various individuals, manufacturers and others concerning recent advances in the world's technology. Owing to the present restricted staff, and also owing to the limited funds available for the purchase of literature, the activities of this Bureau are necessarily being carried out on a smaller scale than their importance warrants.

During the period covered by this report a large number of written inquiries was answered and in addition many verbal inquiries were dealt with. The

information given covered many branches of industrial activity, as the following instances indicate :—

(*a*) *Mineralogical.*—Uses, prices and technology of magnesite, earth-colours, barytes, felspar, slate-waste, mica, gypsum, &c. Methods of extraction of phosphorus from various mineral phosphates. Information concerning various oil-shale retorts. Utilization of bentonite.

(*b*) *Metallurgical.*—Specifications for the varieties of iron and steel to be used with different methods of welding in the manufacture of chains. Production of malleable iron castings. Manufacture of balls and ball bearings. Production of arsenic from its ores. Treatment of gold ores. Information concerning a slime concentrator.

(*c*) *Forest Products.*—Information concerning timber and varnish for bobbins ; the fire-proofing of wood ; utilization of sawdust ; charcoal and wood distillation ; artificial seasoning of hardwoods ; dyes from eucalypts ; essential oils from Australian plants ; preservation of timber from fungi, dry rot, white ants, &c.

(*d*) *Foods.*—Dehydration of various vegetables, manufacture of glucose, preservation of orange juice, vacuum process for the storage of fruit, &c.

(*e*) *General.*—Manufacture of plaster of Paris, water-glass, Epsom salts, sulphate of ammonia from gypsum, thymol, asbestos-cement sheets, nicotine sprays, catgut, kalsomine, lanoline, glue, luminous paint, &c. Methods of fireproofing fabrics, cementing metal to glass, joining tortoise shell, glazing tiles, glazing concrete, drilling glass, &c. Reports on methods of obtaining power from windmills and from sun heat, for the control of boilers, for the production of gas from eucalyptus leaves, &c.

(*f*) *Miscellaneous.*—Throughout the year the Bureau also gave a considerable amount of information to various Commonwealth and State Government Departments and reported on various processes submitted to it.

In the course of carrying out its activities, the Bureau has often been asked for information concerning the exploitation of certain Australian products. In some cases no general standard for the product can be laid down, and it thus becomes necessary to submit samples to consumers in order to ascertain whether or not the material is suitable. For the individual producer of a new material it is often difficult to quickly ascertain the whereabouts of the different consumers. In regard to the examination of samples, this Institute

has been fortunate in obtaining the ready co-operation of various consumers, and in this way has been able to do valuable work. In certain cases it has been considered advisable to submit samples to interested firms in other countries, and in this connexion the help of the High Commissioners in New York and London has been enlisted. The recent equipment of a laboratory for the Institute in Melbourne will be of very material assistance in this class of work. Many of the recipients of the above information have sent letters expressing their appreciation of the information received. A selection of extracts from such letters is :—

" The information to hand is complete and concise and is just what I was looking for."—A firm of patent attorneys.

" I would like to express my thanks to yourself and staff for the trouble they have taken to collect this interesting information, which I feel sure will prove of very considerable value."—A State Irrigation Area.

" The information contained therein is most interesting and useful."—A manufacturing company.

" I have carried out a number of experiments as suggested by you with very good results."—A manufacturer.

" I have to express our gratitude and thanks for the assistance given us in you letter."—A manufacturing company.

" We are much obliged to you for the helpful suggestions contained in yours of the 14th."—A manufacturing company.

" The matter of your letter will be most valuable and will save us an incalculable amount of experimenting."—A firm of engineers.

" Your kindly interest is much appreciated by me, and I thank you sincerely for the valuable information you have already given."—A prospector.

" I beg to thank you for the valuable information furnished therein."—A State Department of Agriculture.

" I desire to express my thanks for the valuable information you have supplied."—A State Water Commission.

" For the full and comprehensive nature of the letter and the helpful matter in the pamphlet I thank you."—A State Department of Agriculture.

" Your very kind and comprehensive data relative to the manufacture of ..... to hand. I thank you very much for your assistance."—A manufacturing company.

"The information you have given will be of great value."—A museum.

"I wish to thank you for the amount of interest apparently extended. The suggestions for marketing the ..... are much appreciated."—A prospector.

"We take the opportunity of thanking you very much for the interest taken. It has certainly helped us considerably in remedying the trouble."—A manufacturer.

"I am in receipt of your report. I have to thank you for this and to assure you that it will be of the greatest assistance to us."—A manufacturer.

IV.—AGREEMENT AT PREMIERS' CONFERENCE FOR CO-OPERATIVE INVESTIGATIONS BY INSTITUTE AND STATE DEPARTMENTS.

A mere glance at the activities of scientific research organizations in other parts of the world will disclose the fact that these are on a broad basis, national in their purview, and are well subsidised. Consistently with this, the statutory functions of the Institute embrace pure scientific research as well as scientific researches in connexion with, and for the promotion of, primary and secondary industries; the making of grants to enable research to be carried on; the awarding of industrial research studentships and fellowships; and the standardization of industrial and scientific apparatus. It is no essential or normal part of the Institute's work to confine itself to matters in which there can be co-operation with the States; and it would be a calamitous and non-statutory limitation if such a policy were to be allowed to govern the Institute. Obviously, however, there are often researches in which one or more States are directly interested, together with the Commonwealth, and for which there is neither the existing provision in *personnel* or scientific or technical equipment in either State or Commonwealth. Hence, the question of co-operation between the Institute and State Government departments, such as Agricultural and Mines departments, is of high importance, and as such was discussed at the Conference between Commonwealth and State Ministers, held at Melbourne in May, 1923. The opinion was generally expressed that in view of the present population, resources and stage of development of the States, at least some of the scientific and technical problems which are of national importance or which affected two or more of the States could very properly be carried out on a co-operative basis by or through the Institute. In a memorandum issued by the Commonwealth Government to the State Governments prior to the date of the Conferences, the Commonwealth's proposals for co-operative work were outlined and the general nature of the problems in regard to which it was proposed that such a commencement could be made immediately, was indicated. The memorandum is printed as an Appendix to this Report. This, of course, is merely one aspect of the Institute's proper activity, and as above stated, by no means defines its sole function or its normal activity.

The result of the discussion at the Conference was that the States agreed to the Commonwealth proposals. In the course of discussion the Prime Minister (the Rt. Hon. S. M. Bruce, P.C., LL.D., M.P.) stated that "We should have to submit what we proposed [in this regard] to the States from time to time, and if it met with their concurrence we should take the necessary action . . . ." He also said that before the Commonwealth took any definite steps he would submit his proposals to each of the States.

It is not unimportant to point out in this connexion that there appeared to be on the part of some of the members of the Conference an extraordinary misconception as to the real nature of the requirements for the successful prosecution of scientific investigations. For example, it was suggested that the Institute should first prove that it is "able to do useful work," and in this way "justify its existence," it being overlooked that this was *before* steps were taken to provide it with proper resources in the way of funds and expert staff. That it was to demonstrate its abilities without funds and staff discloses, of course, the immaturity of the consideration of the whole position.

It has already been pointed out in another part of this Report, firstly, that the scope of the functions of the Institute are very wide indeed and that it is the first instance in which a Government has created a single organization to carry out scientific industrial research in practically every branch of applied science and of industry, and, secondly, that the funds and staff so far provided for the Institute are almost ridiculously small compared even with those which have been provided for National Research Institutions in other countries, although the scope of the work of the latter may be very much smaller than that of the Institute.

It cannot be too strongly insisted that the successful prosecution of scientific research involves not only considerable time and expense, but also the employment of experts possessing very high qualifications. The day has passed by when it was possible for achievement in scientific research to be made by men who have not had the advantage of specialized training and experience, and who did not possess the intricate and accurate apparatus and appliances which are now necessary. The problems which it is the function of the Institute and which it is very often asked to investigate ordinarily require continuous research by highly qualified experts; it is idle to expect that such problems can ordinarily be solved by the expenditure of only a very limited sum and but a few months of research.

In the case of those few problems for the investigation of which the Institute has been provided with adequate funds, notably the prickly pear and the paper-pulp investigations, advances of the very greatest importance have already been made. In both these cases there is every reason to believe that the scientific and technical aspects of the problems will be completely solved before long. This is only what could have been expected, and shows quite clearly—if indeed any demonstration were necessary—that it is

unreasonable—indeed absurd—to expect valuable results from scientific research work unless adequate facilities for conducting the work are made available. This has, of course, been fully realized in other countries which have established National Research Institutions. In those countries a policy of first " making good " with wholly inadequate resources in *personnel* and material is not only not countenanced, but would be recognised, as indeed it must be by any one who gives the matter appropriate consideration, as out of the question.

V.—PROPOSALS FOR FURTHER CO-OPERATION WITH THE STATES.

In order to give effect to the agreement which was reached at the Premiers' Conference and to the promise made by the Prime Minister to submit definite proposals to the States, a programme of co-operative work was prepared by the Institute and forwarded to the Commonwealth Government in November, 1923, with a recommendation that the necessary funds be made available.

It was pointed out that the following *new* contributions for co-operative work had *recently* been either paid or offered by the States :—

1. *Paper Pulp Investigations*—	
New South Wales, Victorian, and Tasmanian Forests Departments, £250 each	750
2. *Timber Testing*—	
New South Wales Forestry Department	250
3. *Citrus Fruit Investigations*—	
New South Wales Conservation and Irrigation Commission—	
(*a*) Contribution to cost of investigations	1,000
(*b*) Estimated value of area for experiment station..	1,500
Total	3,500

The total sum contributed or promised by the States to the Institute during the last three years (1920–23) is no less than £24,500.

Not only the above offers, but also the whole history of the operations of the Institute, testify that the States are generally anxious to co-operate with the Institute. Owing to lack of funds, the Institute, however, has not yet been able to meet the States half way and to comply with reasonable requests for co-operation. If the Institute is not provided with the necessary funds to comply with the States' requests for co-operation, and to give effect to the agreement reached at the Premiers' Conference, the Institutes' work will, of course, receive a severe set-back.

So far, the scheme for co-operative work submitted to the Commonwealth Government has been on a very restricted basis, and provides for an annual

expenditure by the Institute of only £8,100 and for a capital expenditure of only £4,000 as follows :—

COST OF PROPOSED CO-OPERATIVE INVESTIGATIONS WITH STATES.

—	Estimated Annual Expenditure by Institute.		Capital Expenditure.	
	£		£	
I.—Agricultural and Federal Problems.				
A.—Plant Diseases—				
1. Citrus Fruit Diseases	1,000		..	
2. Maize, Millet, and Sorghum Diseases ..	600		..	
3. Potato and Tomato Diseases	600		..	
4. Brown Rot of Stone Fruit	250		..	
B.—Animal Diseases and Pests—				
1. Buffalo-fly Pest	900		..	
2. Kimberley Horse Disease	700		..	
		4,050		..
II.—Forest Products Investigations.				
1. Timber Mechanics and Physics	500		2,500	
2. Timber Seasoning	350		..	
		850		2,500
III.—Economic Mineral Resources.				
1. Preparation and Publication of Bulletins ..	1,000		..	
		1,000		..
IV.—Manufacturing Industries.				
1. Pottery and Glazes	500		..	
2. Paints, Enamels, and Varnishes	500		..	
3. Miscellaneous	500		..	
		1,500		..
V.—Fuel Research.				
1. Production of Liquid Fuels from Australian Raw Materials	700		1,500	
		700		1,500
		8,100		4,000
Grand Total				

The outline of the schemes for co-operative work forwarded in November, 1923, for the approval of the Commonwealth Government for submission to the States is as follows :—

Premiers' Conference, May, 1923.—Outline of Proposals for Further Co-operation with States.

I.—Agricultural and Pastoral Problems.

The field of work for the investigation of problems affecting the agricultural and pastoral industries is obviously too large to enable an immediate commencement to be made in a thoroughly comprehensive manner. It is, therefore, proposed for the present to restrict the investigations to certain

problems relating to plant and animal diseases and pests. In the past, investigations on these pests in Australia have been largely the outcome of individual effort. There has been little combined "team" work on a co-operative basis, such as has been carried on so successfully in the United States of America and other countries. This is, of course, the very class of work which it was intended the Institute should undertake.

Attention has frequently been directed to the enormous losses which these diseases and pests entail. Popularly their magnitude is scarcely realized. For example, it is estimated that the *annual* average loss from plant diseases alone is not less than £6,000,000. The loss from animal diseases and pests is probably very much greater. It is obvious that if any of these diseases can be controlled or eradicated at reasonable cost it would be of great direct benefit to the Commonwealth; it would reduce the cost and increase the volume of production.

The Institute has already received many requests from State Governments, organizations and associations of primary producers and other sources to undertake investigations of these problems. Certain of the State Governments, *e.g.*, New South Wales and Western Australia, have voluntarily offered to share in the cost, but up to the present the Institute has not been able to accept these offers owing to lack of funds.

It is recommended that a beginning be made in co-operative investigations on the following problems :—

A.—PLANT DISEASES AND PESTS.

1. Citrus Fruit Diseases.

Certain diseases of citrus fruit cause heavy losses, and the methods at present adopted for controlling attack, more especially of black spot on oranges and brown spot on mandarins, do not give much assurance of success. In 1922 the value of oranges and mandarins produced in New South Wales alone was £777,000.

In addition to the actual loss of much fruit through diseases, the market value of a large proportion of the crop is reduced owing to "spotting." A conservative estimate of the annual loss gives a sum of £135,000.

In the past three or four years the Institute has received requests to undertake investigations of these problems from various sources, including the Fruit Growers' Association of New South Wales, the New South Wales Department of Agriculture, the Australian Citrus Growers' Association, and the New South Wales Water Conservation and Irrigation Commission. The following is an outline of the co-operative scheme of proposed investigation :—

Co-operating Bodies.—New South Wales Fruit Growers' Association, New South Wales Water Conservation and Irrigation Commission, State Departments of Agriculture.

Investigator and Assistants.—The investigator and laboratory assistants necessary for this work would also be engaged in duties in connexion with other proposed plant disease work. An experienced assistant would be required, and at least two senior laboratory assist-

ants and two junior assistants would be necessary to carry on this work in conjunction with the investigations on maize, sorghum, and millet diseases and potato and tomato diseases (*see* hereafter). For the commencing salaries of the four assistants a sum of £1,046 is included. These assistants would be engaged not only in work on citrus fruit problems, but also in investigations on maize and millet, tomato, and potato diseases.

Expenditure.—It is estimated that the total expenditure to the Institute on citrus fruit disease investigations would be at the rate of £1,000 per annum.

Work.—The investigations would cover a wide range involving (*a*) the isolation and culturing of fungi and bacteria associated with the conditions, the determination of parasitical or non-parasitical forms, conditions favouring development of attack, host relations, damage and methods of control; (*b*) the cause of mosaic and leaf-mottling; (*c*) soil conditions and fertilizer requirements, gum formation, &c.; (*d*) inflorescences, distribution of fruit buds, bud formation, dropping of fruit, exanthema, &c. Facilities for the necessary field work would be provided by the co-operating bodies. The laboratory work would be carried out at the Institute's laboratory at Brunswick.

2. Maize, Millet, and Sorghum.

There is an ill-defined group of fungi that cause serious diseases to maize, sorghum, and millets. These diseases are popularly called blight, leaf-stripe, leaf-wilt, ear-rot, moulds, &c. One of the most common causes of such diseases appears to be the fungus *Helminthosporium*. The life history of the fungi and their effect on germination are unknown, hence proper methods of control cannot at present be indicated. Some of the fungi are known to cause root, seedling, or stalk infection. The specific determination of these fungi and the damage associated with such require considerable investigation in co-operation with the entomologist and plant breeder.

Great losses are experienced through these diseases in the corn growing parts of New South Wales and Queensland and to a less extent in Victoria. It has been estimated that in some cases as much as 20 per cent. of the crop is destroyed. An average loss of 15 per cent. gives a loss of over £300,000 per annum for maize alone.

Co-operating Bodies.—State Departments of Agriculture, especially New South Wales, Victoria, and Queensland.

Investigator.—Arrangements could probably be made for an expert officer of one of the State Departments of Agriculture to undertake the field work. Reference to laboratory assistance has been made under the heading of citrus fruit investigations.

Expenditure.—The total estimated expenditure by the Institute would be at the rate of £600 per annum.

Work.—The investigation involves the working out the life history and method of attack of each fungus. Investigations would also be carried out to determine the effects on germination, which fungi infect seed internally, method of treatment of infected seed, relation of insects of distribution of disease, methods of control, determination of susceptibility of species, the search for resistant varieties, culture work and experimental inoculations, field selection, seed treatment. The State Departments of Agriculture would co-operate in carrying on field work on a uniform basis. The laboratory work would be carried out by the Institute at its laboratory at Brunswick.

3. Potato and Tomato Diseases.

The potato and tomato are attacked by many species of fungi in common. During the past four or five years, the so-called " spotted wilt " of the tomato has seriously affected production in Victoria and has spread through New South Wales into Queensland. The cause of wilt is still unknown. Pathologists have been investigating the disease for four or five years. A practical method of control is not likely to be evolved until the nature and cause of the disease are known. There are other diseases such as Fusarium wilt and Septoria spot of tomato and leaf-roll of potato which urgently require investigation. In 1919, tomato wilt destroyed half the crop in Victoria.

The Commonwealth production of potatoes in 1921 was valued at £2,260,000. Placing the annual average loss at the conservative estimated rate of 10 per cent., this would be equivalent to an annual loss of £226,000 for potatoes alone.

Co-operating Bodies.—State Departments of Agriculture, Primary Producers' Associations, &c.

Investigator.—As already stated the work would be carried out in conjunction with other proposed work on plant diseases. The field work would be carried out probably by the Victorian Department of Agriculture.

Expenditure.—The total estimated expenditure is at the rate of £600 per annum.

Work.—The first problem to be taken up should be the spotted-wilt of tomato. Investigations to isolate the causal organism and to determine whether the disease is of the nature of mosaic, caused by a filterable virus. Investigations to determine the properties of such virus ; resistance to drying and exposure to sunlight, heat, and disinfectant ; relation to soil and weather conditions, &c. Investigations would also be carried out subsequently on other diseases of tomato and potato.

4. Brown-rot of Stone Fruit.

This is the most serious disease of stone fruits and occurs wherever they are grown in Australia. Great losses are experienced not only in the orchard, but also during packing, transportation and marketing. It is safe to say that one-third of the stone fruits produced is wasted through brown rot.

There are certain unknown details of importance in our knowledge regarding the fungus which causes the rot, and many confusing results have been obtained in the various attempts at control. It is estimated that the average annual loss due to this disease is not less than £500,000.

Co-operating Bodies.—State Departments of Agriculture, New South Wales Water Conservation and Irrigation Commission, Fruitgrowers' Association.

Investigator.—A considerable amount of field work will be necessary, and this would probably be carried out by officers of the State Departments of Agriculture. Laboratory investigations would be made at the Institute's laboratory at Brunswick by officers whose appointment is proposed in connexion with other fruit diseases.

Expenditure.—If the necessary facilities are provided for other proposed work in connexion with plant diseases, the extra expenditure for investigating this disease will be at the rate of £250 per annum.

Work.—Collection of specimens and isolation of fungus. Factors for growth of the fungus, determination of the exact time of infection, and nature of infection. Spraying periods and methods and quantities of spray, varietal resistance, minimum number of sprayings and minimum strength necessary, investigation of methods of picking, packing and marketing to reduce much loss during transport, &c. Experimental treatment of fruit.

B.—ANIMAL DISEASES AND PESTS.

1. Buffalo-fly Pest.

This fly is a serious pest in the Northern Territory, and it is probably only a matter of time, unless preventive measures are taken, before the fly spreads to other parts of Australia. It is quite likely that it might thus become a more serious pest even than the cattle-tick, which has already reached New South Wales, Queensland, and Western Australia from the Northern Territory, and which has already, in the aggregate, resulted in losses to Australia amounting to millions of pounds sterling.

The Institute has received requests from various sources to undertake an investigation of this pest. It has collected all available preliminary information, but has not yet been able to undertake any investigations of the problem owing to lack of funds.

Co-operating Bodies.—At the present time this pest is mainly confined to the Northern Territory. The Institute has received requests from various pastoralists' companies and other persons interested, to undertake an investigation thereof. These companies have offered to co-operate and afford facilities for the work. The Queensland Department of Agriculture and Stock would probably also be willing to co-operate.

Investigator.—It would be necessary to appoint a qualified officer to devote his full time to the work which would be carried on under the general control of a Special Committee, consisting of representatives of the various interests concerned.

Expenditure.—The total estimated annual cost to the Institute is £900 per annum. Since this estimate was prepared the Western Australian Government has agreed to contribute on a £1 for £1 basis with the Institute.

Work.—The investigations would comprise (*a*) collection and identification of species, (*b*) life-history and habits, (*c*) distribution, (*d*) methods of treatment and repellants, (*e*) methods of control by parasites and predators. The work would be carried out partly in the field and partly at the Institute's laboratory at Brunswick. If necessary, arrangements could probably be made for part of the work to be carried out by the Queensland Department of Agriculture and Stock.

2. Kimberley Horse Disease.

This disease is particularly prevalent in the Kimberley district of Western Australia, and is a very serious drawback to the settlement of that district. Information collected by the Institute indicates that in the West Kimberley about 30 per cent. of the horses die every year, and in the East Kimberley, about 5 or 6 per cent. The same disease seems to occur in the Northern Territory, where it is popularly known as " Walk-about Disease," and in parts of Queensland, where it is termed " Birdsville disease." Its occurrence has been reported for many years, but comparatively little is known regarding its pathology. It is a serious impediment to successful horse breeding over a large area of Northern Australia.

The Institute has received various requests to undertake an investigation, *e.g.*, from the Western Australian Government and Pastoral Companies. The Western Australian Government has offered to contribute up to £500 on a £1 for £1 basis with this Institute, but no funds have been made available to enable the Institute to play its part.

Co-operating Bodies.—Western Australian Agricultural Department, Veterinary Branch; Western Australian Board of Health Laboratory; Pastoralists' Association; Kimberley Development Inquiry Committee; possibly, Western Australian Aborigines Department and Commissioner of Police, Western Australia.

Investigator.—It would be necessary to appoint a qualified veterinary graduate to devote his full time to the work. Laboratory work would be carried out partly at the Western Australian Health Laboratory, Perth, and partly at this Institute's Laboratory, at Brunswick. Field work would be carried out in co-operation with various bodies in Western Australia.

Expenditure.—Total estimated annual expenditure is £1,200, but the Western Australian Government has offered to contribute up to £500 on a £1 for £1 basis, so that the annual cost to the Institute would be £700.

Work.—Investigations would involve (*a*) examination of horses suffering from the disease, (*b*) clinical and pathological examinations, (*c*) pathology of tissues, (*d*) examinations to ascertain whether disease is due to injurious or poisonous plants, (*e*) examination for parasites, (*f*) laboratory examination of blood smears, &c. Field work would occupy from three to six months, after which laboratory work would be undertaken.

II.—FOREST PRODUCTS INVESTIGATIONS

1. Timber Mechanics and Physics.

It is proposed to carry out systematic tests to ascertain the mechanical properties of timber, such as resistance to bending, compression, tension, shearing, and also into the physical properties such as wood-structure; porosity, holding-power for nails, screws and spikes; and variations in size and volume caused by changes in humidity.

From the industrial stand-point alone there is urgent need for investigations of this nature. Until accurate data are available the present haphazard method of selecting local woods for special purposes will continue, and the cost of this "trial and error" method would ultimately be very much greater than that of a systematic investigation. In addition to providing a basis for the intelligent utilization of many Australian timbers for special purposes, the results of such an investigation would furnish the data necessary for the computation of sizes of various timbers required in constructional work. The results of the investigation would thus provide valuable information for all the timber using industries, as well as for architects, engineers, and the building trade. It would also lead to the conservation of timber supplies by indicating the uses to which inferior timbers may appropriately be put.

Co-operating Bodies.—State Forests Departments, the Federated Waggon, Coach and Motor Body Builders' Association, and other associations of persons engaged in the timber-using industries.

Investigator.—Investigations would be carried out under the supervision of the existing staff of the Institute. It would be necessary to appoint a University graduate to take charge of the experiments at an initial salary of, say, £350 per annum.

Expenditure.—In addition to the salary of the investigator it would be necessary to obtain a special testing machine to enable the experiments to be carried out on the accepted international standardized basis, so that the results obtained from Australian timbers would be directly comparable with those carried out in Forest Products Laboratories in other countries. For this purpose, during the first year of the experiments it would be necessary to purchase an Olsen testing machine of 30,000 pounds capacity, with necessary adjustments, &c., at a cost of £2,500. The total expenditure would thus be £2,500 for testing machine, £500 for other (annual) expenditure.

Work.—The experiments would comprise a complete series of static, bending, tension, compression, shearing and cleavage tests on all Australian timbers of economic importance. At the outset the tests would be on small specimens. Later, arrangements could be made for tests on large specimens.

2. Timber Seasoning.

Artificial seasoning of timber is now very extensively used in other countries. In Australia no systematic tests have been carried out to ascertain the proper conditions for the seasoning of different timbers, *i.e.*, in regard to temperatures and periods of treatment. Australian timbers possess special physical features and must be studied carefully. Systematic kiln tests must

be carried out under proper control before schedules can be laid down for kiln drying, as has been done in other countries. The investigations would be of direct material value and benefit to the timber-using industries of the Commonwealth.

Co-operating Bodies.—State Forestry Department and Industrial Associations in timber using industries, &c.

Investigator.—The work could be done under the supervision of the existing staff of the Institute. It would be necessary to appoint as assistant investigator.

Expenditure.—It is anticipated that the direct expenditure to the Institute will be relatively small as it is hoped that it will be practicable to make arrangements for utilizing the kilns in Victoria which have been erected by the Victorian Forestry Commission and others. The necessary samples for testing would be supplied on a uniform basis by the State Forestry Departments. The necessary additional expenditure would be at the rate of £350 per annum.

Work.—The experiments would be carried out for the purpose of preparing schedules for the kiln drying of all the important industrial timbers. The timber seasoning work would be carried out in conjunction with the tests on timber mechanics. Schedules of the results both of the mechanical tests and of the seasoning tests would be distributed to the timber trades with explanatory remarks showing the advantages to be gained by kiln drying. Facilities would also be given for the training of kiln operators at the experimental kilns so as to provide skilled labour for commercial kilns.

III.—ECONOMIC MINERAL RESOURCES OF AUSTRALIA.

With a view to the development of the mineral resources of the Commonwealth it is proposed to issue a series of Bulletins presenting in convenient and co-ordinated form all available information regarding mineral deposits, processes and methods of treatment and economic use. The Institute is already in touch with the State Mines Departments with respect to this matter. It is proposed that the work shall be carried out by the Institute in co-operation with the State Mines Departments, the Australasian Institution of Mining and Metallurgy, the Chambers of Mines, &c., and that it shall be conducted under the general control of a Special Committee, consisting of representatives of the States and of the more important interests concerned.

Co-operating Bodies.—State Mines Departments, the Australasian Institution of Mining and Metallurgy, Chambers of Mines, &c.

Investigator.—It would be necessary to appoint a qualified officer to devote his full time to the work.

Expenditure.—Beyond the salary of the officer and a small sum for travelling and miscellaneous expenses, the only other expense involved would be for the publication of the Bulletins. A total sum at the rate of £1,000 per annum would be required.

Work.—The whole of the work would be carried out in close co-operation with the State Mines Departments. In addition to the co-ordination of existing information, arrangements would be made for any additional research work necessary to be carried out by the existing staff of the Institute.

IV.—MANUFACTURING INDUSTRIES.

1. Pottery and Glazes.

Certain investigations on pottery and the manufacture of high-class white earthenware and vitrified ware from Australian clays are now in progress, and valuable results likely to be of industrial importance have already been obtained. In the agreement which has been approved between this Institute and the Brunswick Technical School for the provision and equipment of a laboratory for the Institute on the premises of the School it is provided that the Institute shall carry on pottery investigations at Brunswick (which is one of the most important centres of the pottery industry). At the present time the total sum available for this work is only £600 per annum, which has to provide for the salary of the investigator and all incidental expenditure. It is proposed to extend this work on the following basis :—

Co-operating Bodies.—State Mines Departments, Pottery School at Brunswick Technical School, manufacturing firms engaged in pottery industry.

Investigator.—The work would be carried out under the direction of the investigator already appointed. It would be necessary to appoint an assistant.

Expenditure.—The total estimated additional annual cost is £500.

Work.—The investigations would aim (*a*) at devising methods for getting rid of the iron and titanium oxides which are generally present in Australian clays and which cause discolouration in pottery manufactured from them, (*b*) at rendering assistance and advice to persons engaged in pottery industries, especially in regard to such matters as temperature control, methods of preparation, treatment, &c.

2. Paints, Enamels and Varnishes.

The Institute has been asked by the Inter-State Railway Commissioners' Conference and other authorities to carry out investigations on the manufacture of paints, enamels and varnishes from Australian material.

Co-operating Bodies.—The Commonwealth and State Railway Commissioners, Commonwealth Engineering Standards Association and Manufacturers.

Investigator.—It would be necessary to appoint a qualified investigator to devote some months on full time to the work which would be carried out under the general control of a special committee representing the various interests concerned.

Expenditure.—Total estimated annual cost is £500.

3. Miscellaneous.

In connexion with the work of the Bureau of Information of the Institute a large number of requests for information and advice on problems affecting manufacturers are received. Up to the present replies which are sent are based mainly on the existing information available as the result of bibliographical search. Now that the Institute's laboratory at Brunswick is ready for occupation the value of this class of work and of the advice and information furnished could be greatly enhanced if the services of a qualified investigator were available. The estimated expenditure for this work would be at the rate of £500 per annum.

V.—FUEL RESEARCH.

The world-wide importance which is attached to research work on fuels, especially with a view to the economic utilization of solid fuels and the production of liquid fuels is well known. Other countries have established national fuel authorities and are expending large sums on research in these problems. In each country the fuel problem has special features and no country can rely safely on the investigations which are being carried out elsewhere. In Great Britain a Fuel Research Board has been established and is specializing on the question of low-temperature distillation with a view primarily to the production of smokeless solid fuels and of liquid fuels, both heavy fuels for naval purposes and light fuels for ordinary internal combustion engines. Since the war Germany has carried out extensive research on liquid fuel problems and has developed a new national liquid fuel which can be made in Germany from alcohol, benzol, and tetralin. France is carrying out extensive researches and has recently established an Institute of Scientific Research in order to study this and other problems. Canada has established a Dominion Fuel Board. America, realizing that future dependence on natural liquid fuels cannot long continue, is taking steps to exploit her immense deposits of oil shale.

In Australia on the other hand, there is no national fuel authority in existence in spite of the fact that we are almost completely dependent on overseas supplies of liquid fuels. We possess large deposits of coal, lignite, and oil shale and the formation of a national authority charged with the duty of collecting all necessary information and carrying out research work is urgently desirable.

Some years ago the Institute established an influential and representative Committee in Melbourne to consider the whole problem. The Committee recommended as a first step that a technically qualified officer should be appointed at £500 per annum to act as Secretary. As no funds were made available, further progress could not be made. At a later stage the Institute convened a conference of persons interested in the liquid fuel problem. The trade interests represented testified their earnestness by offering to subscribe up to £5,000 on a £ for £ basis with the Commonwealth. The necessary funds were not, however, made available by the Commonwealth. Recommendations for funds have also been made in the draft Estimates submitted by the Institute for the last three financial years.

The Institute has been able to collect and co-ordinate a large amount of existing information and has recently published the results in Bulletin form. The whole problem is admitted to be of great national importance.

Co-operating Bodies.—State Mines Departments, British Fuel Research Board and other national fuel authorities; industrial associations and various interests concerned.

Investigator.—The first essential step would be the appointment of a trained technologist. This officer could be stationed at the Institute's laboratory at Brunswick.

Expenditure.—In addition to the estimated expenditure at the rate of £700 per annum, a sum of £1,500 would be necessary during the first year for plant and apparatus to enable tests to be carried out on a semi-large scale.

VI.—INSTITUTE'S PRESENT INABILITY TO CARRY OUT PRIME MINISTER'S INDICATIONS OR TO FULFIL ITS STATUTORY FUNCTIONS.

It has already been pointed out that the financial provision for the Institute is quite inadequate : at present it can neither undertake the comprehensive carrying out of its statutory functions, nor engage in many investigations of high importance to Australia, nor undertake general research. The significance of this can be readily shewn. Brief reference has been made to fuel research by the British Department of Scientific and Industrial Research, one only of many similar activities of that Department. In Australia the liquid fuel problem is obviously one of great national importance. The Institute has on various occasions recommended that funds be made available for the initiation of fuel research, and has received offers of contributions from the trade interests concerned (see page 60). The recommendations were not, however, approved. This is an instance in which the Institute had not only taken all necessary initial action for the investigation of an important problem, but obtained also the full sympathy and co-operation of the industries concerned, but, nevertheless, has not been able to proceed further owing to inadequate provision for its normal activities.

Examined in the light of the functions explicitly set out in the Science and Industry Act, and in that of the indications given by the Prime Minister of what the Institute was intended to do, the existing situation cannot be regarded as normal. The disparity between the requirements of the Act and actual possibilities under existing limitations run the risk of creating a false public impression as to the value of a national industrial research organization. State Agricultural and other Technical Departments, industrial and technical organizations, and scientific societies naturally expected that the Institute would play a conspicuous part in the development of industrial scientific work. So far, however, from being able to take the lead in such matters, the Institute at present is unable to meet the various organizations and departments half-way, and to comply with reasonable requests for co-operation. Many of the leading scientific and industrial men of Australia have continued to give their sympathy and gratuitous help to the Institute, in the anticipation that the existing state of affairs must soon terminate, and that adequate financial provision will be made for the Institute. When the necessary provision is made, the Institute will develop its work in accordance with the original scheme approved in 1916, and with the provisions of the Act creating it, and there will then be a ready response on the part of those persons who have co-operated in supporting the movement for its creation.

Briefly, the position is that the Institute at present is financially so limited as to be unable to carry out any considerable part of its statutory functions. With suitable endowment and annual subsidy it could create proper laboratory accommodation and obtain an expert staff ; its utility and value would then increase at a rate out of all proportion to the increased expenditure.

The following are some instances of cases in which the Institute has been asked to carry out investigations, but has been unable to do so owing to lack of funds :—

Requests to carry out Investigations with which Institute unable to comply mainly owing to lack of Funds.

Subject.	From whom Request Received.
1. Tomato Blight	New South Wales Association of Nurserymen and New South Wales Department of Agriculture.
2. Sawdust for Alcohol ..	Saw-millers in various localities.
3. Flying Fox Pest ..	New South Wales Department of Agriculture.
4. Timbers, Utilization of	Coach and Waggon Makers' Association, &c.
5. Fruit Diseases ..	New South Wales Department of Agriculture.
6. Brown Spot in Mandarins	New South Wales Fruit-growers' Association
7. Research in Citriculture	Mildura District Citrus Co-operative Association Ltd.
8. Cold Storage of Fruit..	New South Wales Municipal Cold Stores, and Victorian Department of Agriculture.
9. Maize Grub ..	Queensland Acclimatisation Society.
10. Liquid Fuels ..	Royal Automobile Club of Victoria, and various trade interests.
11. Rabbit Pest ..	New South Wales Pastoral Protection Board, and various other persons.
12. White Ant Pest ..	New South Wales Department of Agriculture.
13. Dairying Investigations	Commonwealth Dairy Expert.
14. Dingo Pest	Miles District Council, Queensland, and New South Wales Zoological Society.
15. Australian Timbers for Aeroplane Construction	Department of Defence.
16. Soil Survey of Australia	New South Wales Farmers and Settlers' Association.
17. Problems in Wine-making Industry	Messrs. Penfold and Co.
18. Economic Mineral Resources of Australia	C.O.G. Larcombe and others.
19. Tuberculosis in Stock..	Queensland State Committee of Institute.
20. Fruit Fly	Australian Conference of Fruit-growers.
21. Phosphatic Rocks of Australia	Agricultural Department, University of Western Australia.
22. Kimberley Horse Disease	Western Australian Government

VII.—APPROPRIATE SCALE OF OPERATIONS.

It is recognised that Australia can hardly hope to develop institutions on the scale of countries having many times its population. But, in view of the magnitude of its territory, the extent of its resources, and the importance of its problems, it may very properly be expected to respond to its national needs in respect of scientific and industrial research *at least* in the ratio of population. How far it falls short at present of this, will appear from a statement of what is being done in other countries.

Summarized Statement of Scale of Operations of Scientific Research Institutions in other Countries.

Institution.	Number of Staff.	Annual Expenditure.	Capital Expenditure.
		£	£
1. *U.S.A. Bureau of Standards*	850	460,000	300,000
2. *U.S.A. Department of Agriculture*	..	7,500,000	..
3. *U.S.A. National Research on Fatigue in Metals*	..	21,000	..
4. *U.S.A. Forest Products Laboratory*	450	140,000	50,000*
5. *U.S.A. Carnegie Institution*	154†	220,000	..
6. *U.S.A. Mellon Institute*	80†	77,000	100,000*
7. *U.S.A. Food Research Institute*	..	14,000	..
8. *U.S.A. Bureau of Mines*	..	110,000	..
9. *Pennsylvania Railway Laboratory*	360	..	60,000*
10. *U.S.A. General Electric Co. Laboratory* ..	150	50,000	..
11. *Eastman Kodak Co. Laboratory*	..	30,000	30,000*
12. *British Department of Scientific and Industrial Research*	..	550,000	..
13. *British National Physical Laboratory* ..	479	213,000	..
14. *British Fuel Research Board*	..	63,000	140,000
15. *British Low Temperature Research Station* ..	..	..	30,000
16. *British Cotton Research Institute*	..	15,600	200,000
17. *Swedish Industrial Research Institute* ..	..	40,000	..
18. *Japanese National Laboratory for Scientific and Industrial Research*	..	..	300,000

* Original cost. † Research officers only.

The preceding figures show the scale on which the modern world is endeavouring to promote the application of Science to Industry; and when one regards the losses of Australia from such causes as plant diseases, the blow-fly pest, the cattle-tick pest, and the prickly pear pest, the magnitude of some of the interests involved is evident, and it is obvious that a necessity exists here for a provision adequate for the purposes for which the Institute was created by Parliament. In reviewing the whole position, one is struck by the way in which the actual scientific needs of industry are being met elsewhere. To quote only a single instance: The Shirley Institute in Manchester, recently erected, has a capital grant of £200,000 (£50,000 initially, £30,000 annually for five years) and an annual expenditure of £15,600 for the study of cotton alone.

While it is not suggested that Australia can at present emulate what has been done in older and wealthier countries, it is proper to realize that, since the first steps were taken for the establishment of the Institute, the general

situation has not advanced as it should have done. It is useless to hope to attack industrial scientific problems satisfactorily unless the Institute has the necessary equipment in *personnel* and material, and can employ highly-qualified experts. In this connexion it is well to bear in mind that the necessity for establishing national research organizations has been recognised in Canada, New Zealand and South Africa; in each a commencement has been made in the creation of such institutions.

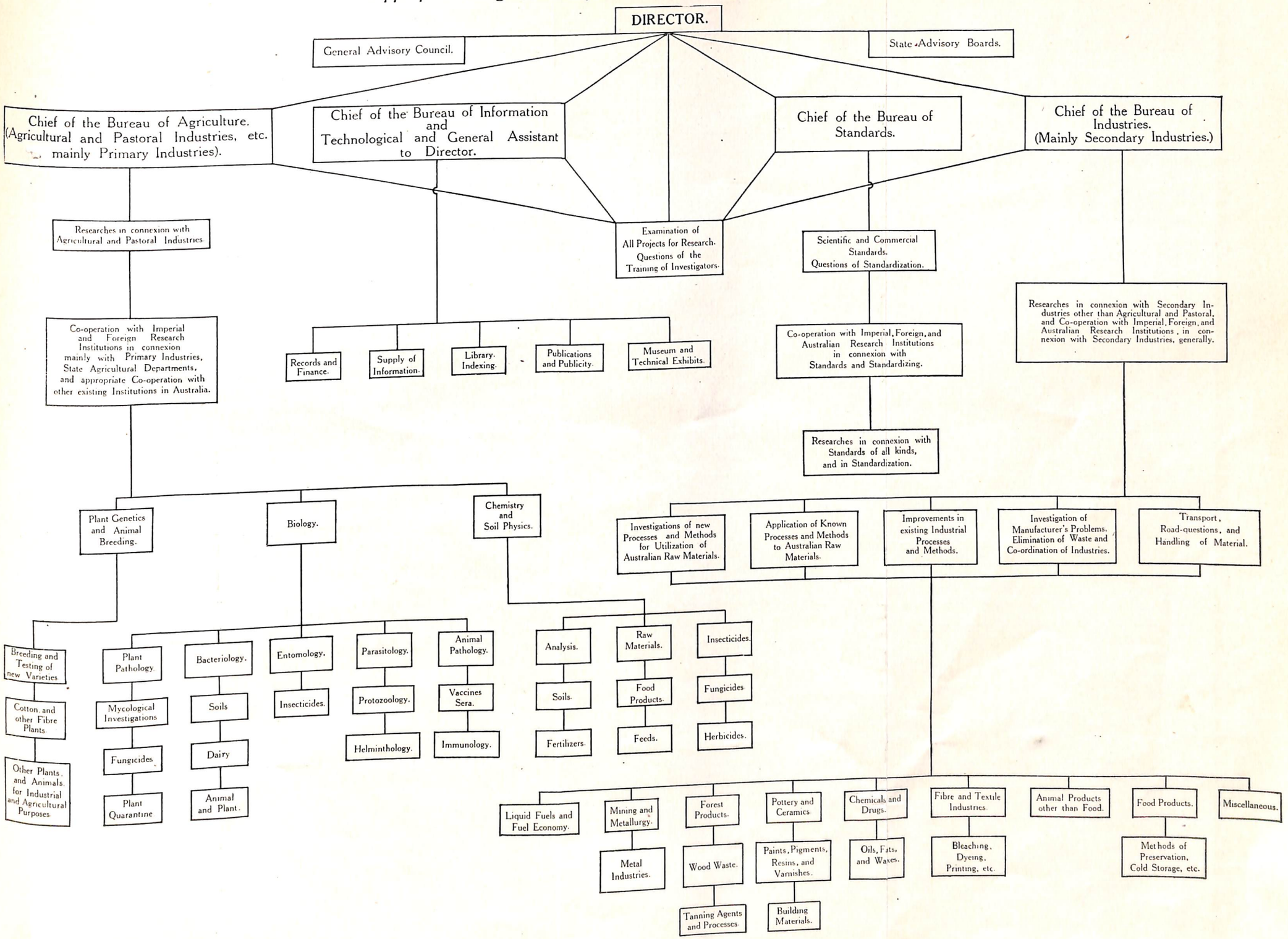
The accompanying diagram, which was attached to a Report forwarded by the Director to the Commonwealth Government in 1921, represents in a general way the scheme of the organization and work of the Institute when it shall have been approximately developed. It is obvious that the establishment on this comprehensive scale will cost a considerable sum of money and can be effected only in the course of years. Initially, its scope, work, and functions will certainly have to be concentrated on the more important branches of the work, owing to limitations both of finance and *personnel* (*e.g.*, shortage of trained investigators).

The significance of the existing position is seen only when it is realized that, to deal adequately with any one of the main branches of scientific industrial research, the expenditure of a substantial sum of money considerably larger than the total vote which has been available in the past for all the purposes of the temporary Institute is required. For example, a complete Forests Products Laboratory cannot be established at a capital cost of less than £40,000 or £50,000, with an annual expenditure of from £25,000 to £30,000; while if it was proposed to undertake standardization work, the cost of a properly equipped Bureau of Standards, even on a relatively small scale, would certainly be not less than £100,000.

Reviewing the whole question of finance in relation to the future policy and programme of work of the Institute, it is recognised that the *efficiency of an industrial research Institute increases rapidly as its scale of operations extends.* This is due partly to the fact that, with a relatively small expenditure such as that of the temporary Institute, the overhead charges for administration, control, &c., cover a considerable proportion of the total funds available. For example, with a total annual expenditure of, say, £15,000, administrative and overhead charges would account for, say, £5,000, equivalent to one-third of the total expenditure; but with a total vote of, say £30,000, the overhead charges would be only slightly increased, leaving a very much larger proportion of the funds available for actual investigational work. Secondly, it is the universal experience of scientific research institutes that what may be called the " yield per man " increases rapidly as the number of men co-operating and the size of the establishment are increased.

Actual experience as to the problems presenting themselves for the attention of the Institute show that the scope of its functions, as originally outlined by the Prime Minister and later embodied in the Act, were singularly apposite to the needs of Australia, with its great range of latitude, its diversities of climate and geophysical characters, and at the present stage of development of its primary and secondary industries.

Appropriate Organization for the Institute of Science and Industry.



VIII.—ADVISORY COUNCIL AND ADVISORY BOARDS.

The Institute of Science and Industry Act provides (section 6) that a General Advisory Council and Advisory Boards in each State may be appointed by the Governor-General to advise the Director in reagrd to :—(*a*) the general business of the Institute or of any bureau thereof ; and (*b*) any particular matter of investigation or research. This Council and these Advisory Boards have not yet been created. At a meeting of members of the former Executive Committee of the temporary Institute convened on the 5th April, 1921, the members present expressed their willingness to act temporarily as an advisory body, and to assist in every possible way in the work of the Institute, and to do this gratuitously. The following provisional Council and provisional Boards are accordingly acting until the appointment under the Act of the permanent bodies :—

Provisional General Advisory Council.

D. Avery, M.Sc. ; S. S. Cameron, D.V.Sc. ; G. D. Delprat, C.B.E. ; H. W. Gepp ; Professor T. R. Lyle, M.A., Sc.D., F.R.S. ; C. S. Nathan ; A. B. Piddington, K.C. ; A. E. V. Richardson, M.A., D.Sc. ; Professor J. Douglas Stewart, B.V.Sc., M.R.C.V.S. ; Professor R. D. Watt, M.A., B.Sc.

The following Chairmen of the State Advisory Committees are *ex-officio* members of the provisional General Advisory Council :—*New South Wales*—F. Leverrier, K.C. ; *Queensland*—J. B. Henderson, F.I.C. ; *Western Australia*—Professor J. W. Paterson, B.Sc., Ph.D. ; *Tasmania*—L. Rodway, C.M.G. ; *South Australia*—Professor E. H. *Rennie*, M.A., D.Sc.

Provisional State Advisory Boards.

New South Wales.

Chairman	.. ..	F. Leverrier, K.C.
Members	.. ..	Hon. F. A. Chaffey, M.L.A., Minister for Agriculture ; J. T. Elliott, D.Sc. ; Professor C. E. Fawsitt, D.Sc., Ph.D. ; A. B. Piddington, K.C. ; Professor R. D. Watt, M.A., B.Sc. ; Professor J. D. Stewart, B.V.Sc., M.R.C.V.S. ; J. B. Trivett, F.R.A.S., F.S.S. (Associate Member).
Secretary	.. ..	E. Alfred, Education Department, Sydney.

Victoria.

Chairman	.. ..	Professor Sir Thomas R. Lyle, M.A., D.Sc., F.R.S.
Members	.. ..	Hon. F. E. Old, M.L.A. ; D. Avery, M.Sc. ; W. T. Appleton ; S. S. Cameron, D.V.Sc. ; M.R.C.V.S. ; D. Clark, M.M.E., B.C.E. ; G. D. Delprat, C.B.E. ; H. W. Gepp ; Sir John M. Higgins, K.C.M.G. ; Professor T. H. Laby, M.A. ; Hon. G. Swinburne ; W. Percy Wilkinson, F.I.C. ; A. E. V. Richardson, D.Sc., M.A. ; A. M. Laughton, F.I.A. (Associate Member).
Secretary	.. ..	Gerald Lightfoot, M.A., 314 Albert-street, East Melbourne.

PROVISIONAL STATE ADVISORY BOARDS—*continued.*

Queensland.

Chairman	..	J. B. Henderson, F.I.C.
Members	..	Hon. V. Neil Gillies, M.L.A., Minister for Agriculture; Professor B. D. Steele, D.Sc.; N. Bell, A.M.I.C.E. (Associate Member); A. J. Gibson, M.E., A.M. Inst.C.E., (Associate Member); J. Gibson (Associate Member).
Hon. Secretary	..	Professor H. C. Richards, D.Sc. (Associate Member), William-street, Brisbane.

South Australia.

Chairman	..	Professor E. H. Rennie, M.A., D.Sc.
Members	..	Hon. J. Cowan, M.L.C., Minister for Agriculture; G. Brookman; W. W. Forwood; W. A. Hargreaves, M.A., D.Sc., B.C.E.
Secretary	..	F. W. Reid, B.Sc., School of Mines and Industries, Adelaide.

Western Australia.

Chairman	..	Professor J. W. Paterson, B.Sc., Ph.D.
Members	..	Hon. H. K. Maley, M.L.A., Minister for Agriculture; C. S. Nathan; J. W. Sutherland; S. Bennett (Associate Member); A. Montgomery, M.A., F.G.S. (Associate Member); G. L. Sutton (Associate Member); A. Gibb-Maitland, F.G.S. (Associate Member).
Secretary	..	A. Tomlinson, M.Sc., A.M.Ins.C.E., University of Western Australia, Perth.

Tasmania.

Chairman	..	L. Rodway, C.M.G.
Members	..	H. W. Gepp; H. J. Colburn (Associate Member); Professor J. H. Mackay, M.C.E. (Associate Member); H. M. Nicholls (Associate Member); C. H. Slayter. (Associate Member).

Communications to: Box "U," G.P.O., Hobart.

IX.—LABORATORIES.

The research work of the Institute will in future be carried out in its own laboratories or in those of Universities and technical institutions when they are available. It may be noted that usually Australian laboratories are not equipped with apparatus for conducting "large-scale" experiments, though these are often a necessary intermediate step between the solution of a problem in the laboratory and the profitable application of the solution to the problem as it is presented on a commercial scale.

In the past the work of the Institute has suffered severely owing to the fact that, with the exception of a temporary laboratory at Perth, mainly devoted to Forest Products investigations, the Institute has had no laboratories of its own. The Education Department of Victoria and the Council of the Brunswick Technical School having made certain rooms, built in connexion with the Returned Soldiers' Vocational Training Scheme, available to the Institute for laboratory purposes, a laboratory equipped for general physical and chemical investigations has recently been completed.

X.—EXPENDITURE AND CONTRIBUTIONS BY STATES.

The following statement furnishes particulars of the expenditure of the Institute during the financial year 1922–23 :—

COMMONWEALTH INSTITUTE OF SCIENCE AND INDUSTRY.

Expenditure during Financial Year, 1922–23.

	£	£
1. Salary of Director	2,000	
Salary of Biologist and Science Abstractor ..	625	
Salary of Chemist and Science Abstractor ..	500	
		3,125
2. Contingencies—		
(i) Postage and telegrams	114	
(ii) Office requisites, exclusive of writing paper and envelopes	32	
(iii) Writing paper and envelopes	23	
(iv) Account, record, and other books ..	4	
(v) Other printing	27	
(vi) Travelling expenses	313	
(vii) Temporary assistance..	1,836	
(viii) Miscellaneous and incidentals	674	
(ix) Telephone service	79	
(x) Printing of engineering standard specifications	77	
		3,179
3. Investigations—		
(i) Prickly Pear Investigations	4,000 (*a*)	
(ii) Paper Pulp Investigations	1,760	
(iii) Cattle Tick Dips	137 (*b*)	
(iv) Worm Nodules in Cattle	..	
(v) Sheep Blow-fly—New South Wales ..	..	
(vi) Sheep Blow-fly—Queensland	637	
(vii) Seed Improvement Committee ..	327	
(viii) Viticultural Investigations	779 (*c*)	
(ix) Castor Beans—Queensland	34	
(x) Western Australia—Red-gum Tanning ..	830	
(xi) Tannin Survey, Western Australia ..	..	
(xii) Timber Impregnation, Western Australia	133	
(xiii) Forest Products Laboratory, Western Australia—Maintenance	609	
(xiv) Power Alcohol	69	
(xv) White Earthenware, Ballarat	445	
(xvi) Carburetter and Liquid Fuel Investigation	970 (*d*)	
(xvii) Pan-Pacific Science Congress—Grant ..	3,000	
(xviii) Engineering Standards	500	
(xix) Miscellaneous	182	
		14,412
4. Bureau of Information		1,381
Total		22,097

(*a*) In addition New South Wales and Queensland each contribute £2,000 per annum.
(*b*) In addition New South Wales and Queensland each contribute on a £1 for £1 basis with the Institute.
(*c*) In addition the Mildura Vineyards Protection Board expend £1 for every 10s. expended by the Institute.
(*d*) In addition the Department of Defence and the Navy Office each contributed 10s. for each £1 expended by the Institute.

The above statement shows that the Institute's expenditure on actual investigational work was £11,412 (*i.e.*, excluding the grant of £3,000 for the Pan-Pacific Science Congress). The fact that the total contributions to supplement the cost of the Institute's work amount to £6,058, or 55 per cent. of the expenditure on investigations from the Institute's vote, is *a striking illustration of the extent to which State Government departments and other bodies are prepared to co-operate with the Institute.* If further practical evidence of this willingness to co-operate were necessary *it is shown in the fact that the total contributions received from, or promised by the States during the three years* 1920 *to* 1923, *inclusive, amount to no less than* £24,500.

XI.—ACKNOWLEDGMENTS AND STAFF.

I desire to express my appreciation of the valuable assistance received from a large number of persons throughout the Commonwealth, including correspondents who have forwarded valuable suggestions and information, and authorities on various subjects who have gratuitously placed their knowledge at the disposal of the Institute. My thanks, and those of the Commonwealth as a whole, are also due to the members of the Advisory Council and Advisory Boards, and of the Special Committees who are voluntarily giving their time and skill to the solution of the various problems referred to in this Report.

In conclusion, I desire to place on record my appreciation of the services of the officers of the Institute in connexion with the work on which it has been engaged. The following are the scientific and technical officers of the Institute :—

SCIENTIFIC AND TECHNICAL OFFICERS OF THE INSTITUTE.

1. *Head Office Staff.*

GERALD LIGHTFOOT, M.A., Acting Chief of Bureau of Information.
EWEN MACKINNON, B.Sc., B.A., Investigator and Chief Science Abstractor.
G. A. COOK, M.Sc., B.M.E., Investigator and Science Abstractor.

Pottery Investigations.

R. C. CALLISTER, Investigator.

Paper-pulp Investigations.

L. R. BENJAMIN, in charge of Investigations.
J. L. SOMERVILLE, B.Sc., Assistant.
T. HODGKINSON, B.Sc., Assistant.

Tanning Investigations.

D. COGHILL, in charge of Investigations.

Seed Improvement Committee.

ELLINOR ARCHER, M.Sc., Secretary and Investigator.

SCIENTIFIC AND TECHNICAL OFFICERS OF THE INSTITUTE—*continued*

Viticultural Investigations.

A. V. LYON, B.Agr.Sc., Investigator.

Commonwealth Prickly Pear Board.

J. C. HAMLIN, M.Sc., Officer-in-charge (U.S. America).
W. B. ALEXANDER, M.A., Acting Officer-in-charge in Australia.
L. F. HITCHCOCK, Assistant Microbiologist.
A. P. DODD, Senior Assistant Entomologist.
A. N. BURNS, Assistant Entomologist.
F. H. ROBERTS, B.Sc., Assistant Entomologist.

(Signed) G. H. KNIBBS,
Director.

Commonwealth Institute of Science and Industry,
314 Albert-street, East Melbourne,
1st February, 1923.

APPENDIX.

CO-OPERATION BETWEEN INSTITUTE AND STATE GOVERNMENT DEPARTMENTS.

Memorandum issued by the Commonwealth Government to the State Governments and approved at Conference between Commonwealth and State Ministers, May, 1923.

Application of Science to Industry.

The Parliament of the Commonwealth has passed legislation for the establishment of an Institute of Science and Industry. The immediate object was the establishment of a Bureau of Agriculture, and a Bureau of Industries. The intention of Parliament was not to duplicate existing State organizations, but to confine the operations of the Institute to work not now being undertaken, and to co-operate, where desirable, with the State authorities. Section 13 of the Commonwealth Statute makes special provision in this latter regard. It is considered that practical results of value can be obtained by co-operation with the States in the development and preservation of the national resources of Australia in the matters hereinafter mentioned :—

Importance of Co-operation.

1. A large amount of information of great practical value regarding the natural resources of individual States has been accumulated by State Government Departments and other bodies. With full appreciation of the work which has thus been carried out, and of the valuable publications which have been issued by these State Departments, information concerning the natural resources of the Commonwealth is ordinarily difficult to obtain in convenient and comprehensive form. The immediate need is therefore the systematization of existing knowledge, supplemented by industrial research work on a co-operative basis. If this work were carried out it would enable bulletins devoted to particular resources or immediate industrial opportunities, to be issued from time to time, and special reports to be placed—as occasion arises—before any authorities and individuals in the Commonwealth or abroad who may be expected to base industrial developments thereon.

2. For a work of this magnitude to attain its full measure of usefulness, the cordial support and concurrent effort of the various State Government Departments, and of other organizations, having at heart the welfare of the nation and the development of its resources are obviously essential.

Co-operative Investigation of Agricultural and Pastoral Problems.

3. One important direction in which the resources of Australia may be developed is by the control and eradication of diseases, pests, and parasites affecting the agricultural and pastoral industries. The loss caused thereby to the primary industries of Australia, and to the secondary industries dependent upon them, amount to many millions of pounds per annum. Nearly all the most serious of these pests, &c., now extend to two or more States, and co-operative action is therefore almost essential for their control and eradication.

4. Already certain of the State Agricultural Departments, Universities, and other bodies have carried out valuable investigations in regard to some of these problems, but by reason of the magnitude and difficulty of the problems, this work has generally been of an uncorrelated and, in some cases, fragmentary nature. Before any comprehensive investigations on any such problem can be economically and effectively planned, it is necessary for the most complete information possible to be collected from all sources, and examined by experts in the particular branches of science concerned. Only in this way can the existing state of knowledge and the extent to which the problem has already been solved be disclosed. This preliminary work often involves a considerable amount of labour, and could be carried out most effectively by a Commonwealth organization co-operating with the State Government Departments and other bodies concerned.

5. It is not, of course, suggested that the Commonwealth should interfere in any way with the work of the State Agricultural or other Departments now in progress, but it is submitted that by the pooling of knowledge and resources through the agency of the Commonwealth Institute of Science and Industry, research work on such matters as are indicated below could be carried out more effectively and with greater prospect of success than under existing conditions of isolated effort.

(i) *Stock Diseases.*—A certain amount of research work on various stock diseases has been carried out from time to time in the States. The New South Wales Government is now developing a Stock Disesases Experiment Station at Glenfield, and it is understood that the State authorities controlling that station have expressed their desire to develop it along national lines on a co-operative basis. It is, therefore, proposed that the Commonwealth Institute should co-operate in the work at Glenfield. Co-operative investigations could be carried out on diseases such as (*a*) Braxy disease of sheep, (*b*) Contagious abortion of cattle, (*c*) Contagious pleuro-pneumonia, (*d*) Swine fever, (*e*) Tuberculosis in stock, (*f*) Midland cattle disease, &c. No hard-and-fast rule can be laid down as a basis for co-operation; each case must be dealt with on its merits, and the most suitable scheme evolved to meet the special circumstances of the case.

(ii) *Cattle Tick Pest.*—This pest is a serious menace to the pastoral industry, and it is proposed that a co-operative scheme of eradication between the Commonwealth, New South Wales, and Queensland Governments be prepared and brought into effect.

(iii) *Stock Pests.*—Another important branch of work in which it is thought that the Commonwealth Institute should co-operate with the States and supplement work which has already been carried out, is in parasitological investigations on internal and external parasites affecting stock, in regard to which the study of the life histories of the pests is ordinarily a matter of fundamental importance. This includes such parasites as (*a*) worm-nodule, (*b*) sheep louse fly, (*c*) sheep blow-fly, &c.

(iv) *Eradication of Animal Pests, &c.*—Several of the States have already carried out experimental work with a view to the suppression of animal pests such as (*a*) dingoes, (*b*) flying foxes, (*c*) rats, (*d*) white ants, &c. All these pests affect more than one State, and it is obvious that by co-operative action more effective results may be expected.

(v) *Plant Diseases.*—In this branch of work again several of the States are carrying out investigations. If the example of other countries be followed in Australia, comprehensive investigations should be carried out in a co-operative basis with a view to adopting effective, practical, and economical measures for the control of these diseases, such for example as (*a*) Bunchy top of bananas, (*b*) Tomato wilt, (*c*) Potato diseases, (*d*) Rust and smut of cereals, and (*e*) Brown spot and other citrus diseases.

(vi) *Plant Pests.*—Another important branch of work in which the States are closely concerned, and in regard to which co-operative effort is immediately desirable, is the investigation of the life histories and of the best methods of control and eradication of plant pests, *e.g.*, (*a*) fruit fly, (*b*) maize grub, (*c*) cut-worm, &c.

Forest Products and Timber-using Industries.

6. The conservation of timber and the economical utilization of waste products constitute a field for co-operative research work of enormous potential value to Australia. This has been recognised in other countries where properly equipped and staffed forest products laboratories have been established on a national basis. The cost of equipment of such laboratories is high, and it is obvious that by pooling our resources greater efficiency and economy could be attained, and that the investigations could be carried out more effectively than would be possible if the States each proceeded independently.

It is not suggested that the Institute of Science and Industry should in any way overlap or duplicate the efforts of the State Forestry Departments. Experience has shown, however, as, for example, in the case of the paper-pulp investigations, that research work on problems of this nature can be undertaken most effectively by a Federal organization working in co-operation with the State Forestry Departments.

7. The general nature of experimental work on forest products which should be undertaken by the Institute in co-operation with the States is—(*a*) Preservation of wood against dry rot and attack by white ants, borers, &c.; (*b*) mechanical tests and properties of woods and their suitability for special industrial purposes; (*c*) seasoning of timber; (*d*) chemical and mechanical utilization of waste wood, sawdust, &c.; (*e*) paper pulp, especially mechanical pulp for newsprint; (*f*) tanning agents; (*g*) essential oils, gums, resins, drugs, dyes, &c.

The Economic Mineral Resources of Australia.

8. A large amount of highly valuable information is available in the publications of the various State Geological Survey Departments regarding mineral deposits, but these publications generally contain little information concerning processes for treatment of ores and the economic outlets for the various minerals. Some of the States have also published valuable monographs and articles concerning the economics of certain minerals occurring in the respective States.

9. Comprehensive information concerning the economic mineral resources of Australia is not, however, available in convenient form. Any person desiring to obtain such information—even regarding one particular mineral—at present experiences very considerable difficulty in acquiring it. The existing situation, therefore, impedes the development of our mineral resources. Hence from the national stand-point there is need for co-operation between the Commonwealth and State authorities with a view—(*a*) to the preparation and publication of a series of bulletins each confined to one particular mineral and containing information regarding all known Australian deposits of that mineral, its uses, methods of treatment, markets, &c.; and (*b*) to the carrying out of such research work as may be considered necessary.

Technological Development of Manufacturing Industries.

10. In other countries large institutions have been established to carry on scientific investigations for the development of manufacturing industries. Little attention has, however, been given to this field of work by the Australian States. It is obvious that modern industrial development depends fundamentally upon progress in scientific research, and that no limits can, therefore, be set to the directions in which such research is likely to be of benefit to the manufacturing industries of Australia. It is therefore proposed that a beginning should be made by the Commonwealth Institute of Science and Industry, in co-operation with the States, in attacking problems such as the following:—

(*a*) *Pottery.*—Manufacture of white earthenware and pottery; utilization of clay resources; manufacture of tiles, glazes, enamelled ironware, &c.

(*b*) *Tanning and Fellmongering.*—Improved processes; utilization of Australian raw materials, and development of standard methods.

(*c*) *Paints, Enamels, and Varnishes.*—Investigations to improve processes and standardize products.

(*d*) *Cold Storage and Food Problems.*—Cold storage of meat, fruits, and other perishable products; investigations as to diseases and organisms affecting such products and as to most suitable conditions of storage for export.

Investigation of Water-power Resources.

11. Cheap power is a resource essential to the development of practically all other natural resources. It is virtually as essential as labour and material, in so far as it effects economical production. The extent to which electricity may be applied to cheapen and improve mechanical production, to transportation, to electro-chemical and metallurgical processes, to agriculture, and to domestic labour-saving apparatus is altogether incalculable. Cheap power will tend to reduce the cost of living, to facilitate the payment of higher wages to improve working and living conditions, to decentralize population and encourage rural

development, to maintain a larger population on the soil, to improve the status of the agricultural worker, and to add generally to the prosperity and happiness of the Commonwealth.

12. One of the most important problems which Australia has to face appears to be the organization of rural life, so as to make it richer, more satisfying, more profitable and more pleasant. With this problem the question of water supply and power supply are directly associated. The available sources of power are (*a*) water power, and (*b*) bituminous coal, brown coal, oil shales, &c. No comprehensive records exist which set forth the exact location and characteristics of the water powers of the Commonwealth. Certain of the States have carried out a considerable amount of investigational work on this matter. As the question of hydro-electric development and cheap power supply are of supreme importance to the development of natural resources, it is proposed that the Institute of Science and Industry, in co-operation with the State authorities concerned, should undertake the compilation and publication of a bulletin presenting the information in suitable form from a national standpoint.

Economic Utilization of Fuel Resources and Production of Liquid Fuels.

13. The present methods of utilizing fuel are wasteful owing (*a*) firstly, to the fact that power developed rarely exceeds more than 19 per cent. of that theoretically possible, and (*b*) secondly, to the fact that coal, when suitably handled by the chemist, yields a whole series of valuable by-products. Other countries are carrying out extensive research work on the distillation of coal, and it appears fairly evident that the best chances of economical success lie in the distillation of oils from coal, and the utilization of the carbonized residue for the generation of power and for domestic purposes. Several of the States are already vitally interested in the problem of the economic utilization of their fuels, especially brown coal and oil shale. The establishment of an Australian Fuel Research Station, in which the Institute of Science and Industry can co-operate with the States in carrying out experimental work on the economic production and utilization of fuels, is urgently required.

Proposals for Co-operation between Commonwealth and States.

14. With a view to bringing about co-operation between the Commonwealth and States for the development of the natural resources of Australia it is proposed :—

(i) That the State Premiers be invited to concur generally in co-operation between the Commonwealth Institute of Science and Industry, and the respective State Government Departments concerned on the lines indicated above.

(ii) That the State Premiers be invited to concur in particular in—

(*a*) The preparation and publication by the Institute of Science and Industry of a series of appropriate bulletins dealing with the Natural Resources of Australia.

(*b*) The preparation and carrying into effect of co-operative schemes for the control and eradication of Diseases, Pests, and Parasites affecting the agricultural and pastoral industries, and especially for the eradication of the cattle tick pest.

(*c*) The preparation and carrying into effect of co-operative schemes for the solution of problems concerning Forest Products.

(*d*) The preparation and publication by the Institute in co-operation with the State Geological Survey Departments of a series of bulletins dealing with the Economic Mineral Resources of Australia.

(*e*) The preparation and carrying into effect of co-operative schemes for the investigation of problems affecting manufacturing industries.

(*f*) The preparation and publication by the Institute in co-operation with the State Departments concerned of a bulletin on the Water-power resources of Australia.

(*g*) The preparation and carrying into effect of co-operative schemes for the investigation of fuel problems.

(iii) That in so far as the State Premiers, or any of them, approve of the above proposals, they be invited to instruct their respective State Officers accordingly

(iv) That the whole expense of the Bulletins referred to in paragraphs (*a*), (*d*), and (*f*) above be borne by the Institute, but that in so far as the cost of any co-operative research work is concerned (paragraphs (*b*), (*c*), (*e*), and (*g*) above) the State Premiers be asked to concur generally in the principle that the co-operating States will contribute with the Institute on a basis to be agreed upon. The total sum thus contributed by the States may be limited to a definite amount. The general concurrence suggested would ordinarily be subject to specific approval by the State Ministers controlling the Departments concerned in each particular scheme.

By Authority: ALBERT J. MULLETT, Government Printer, Melbourne.