The Proceedings of the 9th Lincoln College Farmers' Conference 1959
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LINCOLN COLLEGE FARMERS' CONFERENCE
1959

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The Chairman, Mr S. C. Bowmar of Gore, welcomed farmers to the conference and introduced

Mr W. H. Gillespie, M.P., Chairman of the Board of Governors.

Mr Gillespie:

On behalf of the Board of Governors and the Staff of this College, I extend to you a very cordial welcome, and to express the hope that your Conference will once again be an outstanding success.

You will see that a start has been made with the building of the George Forbes Memorial Library, something we have been waiting for for a long time. It will be a great benefit to those who administer, those who work on the Staff, and to all students at the College. Of course, we have other plans in regard to other new buildings such as a teaching block and, in particular, a Conference Hall. As I have said before, I have hopes that perhaps farmers might take this matter into their own hands and do something to help us here at the College in that regard.

I want to say what a privilege I think it is to be called on to officially open this Conference. This Conference is looked upon, especially by South Island farmers, as being typical of a Farmers' Parliament where you come together as leaders of our farming community to discuss various farming problems, to listen to points of view put forward by people who are involved in farm administration, and to find better ways of running your own particular farm.

It would not be news to you as farmers to say, as the Chairman has already said, that we have passed through a difficult year with the introduction of the P.A.Y.E. system of taxation which has affected all farmers, the drought which has affected a great part of the South Island, and the fall in the prices of our primary products. At the moment I can think of a fourth case: I believe that the extremely wet weather we have experienced in some districts over the last six weeks will create problems on some farms at least which will be equal to, or worse than, those experienced under the drought.

I have always been very concerned about the introduction of the P.A.Y.E. system of taxation for self-employed persons, and especially the farming community because of its impact on them in the first year of operation. I warned people of what I thought would happen when the Bill was introduced in the House of Representatives. I set out reasons why it would be serious for the farming community. I endeavoured to warn farmers, where I could make my voice heard, of the problems of the system and what it was going to mean. How serious it has been to farmers is borne out by figures of the advances which are having to be made by our commercial firms to tide farmers over. The reason for this is that in February the farming community had to find taxation on their income earned in the previous year just when their returns were in, or almost in, for that deduction year, and then in the next eight months they had to find two further payments under the new system before any more returns came in. In addition as you already know, it entails a great amount of paper work for farmers which, I think, they should not be required to undertake. Of course, some employ accountants to do this work for them. I hope that some of the anomalies will be cleared up. It is fantastic the amount of work required to calculate tax that has to be paid and the amount that has to be paid for the casual employees, like shearsers, and I hope that some better system for casual employees on farms will be devised.

Of the drought I need say nothing.
Though the fall in prices of our primary produce has been serious for the great majority of farmers, I am not pessimistic as to the future because I believe that the co-operation of farmers plus hard work and ingenuity will pull them through. But I am very concerned that farmers are receiving no help whatsoever in reducing their cost structures—something that all farmers have been asked to do.

It is fair for me to say that, since the prices of our primary produce started to fall, our costs have been continually rising, and I believe this will eventually have serious repercussions on the whole of the community.

In our secondary industries it will be necessary, in the future, for full employment to be provided for the people of New Zealand, but in the first instance, prosperity for everyone of us must come from what you produce in our primary industries. If, in the future, there is no incentive for the primary producer and if provision is not made for returning some earnings to the land as has been the trend in this direction over the last seven or eight years, then I believe all will not be well for the rest of the community. I am sure you will all agree that the best insurance we have in these days for all people of New Zealand is to have our farming lands in good shape so that we may continue the expansion in farming which has been so patent over the last two years. This was brought about, in a large measure, by agricultural research plus the ingenuity of the farmer to take out of the results of research the things that can be fitted into his own farming methods and so give to the people of New Zealand the benefit of added production.

I again, on behalf of the Board of Governors and the Staff of this College, extend a very cordial welcome to you here at this Conference. I hope and trust that its purpose will be fulfilled, and it gives me much pleasure in declaring your meeting officially open.
I welcome the opportunity extended to me today to speak to you on "Some Aspects of International Agriculture". Farmers have three main ways of considering their position. There is the purely personal viewpoint—how they are affected in relation to their neighbouring farmers, and other sections of the community. Secondly, there is the national view—how New Zealand farmers fare against farmers of other nations. Finally, there is the international aspect in which world agriculture compares and contrasts its position with other sectors of international economic activity. It is with this overall position that I have had some recent experience, and I consider it behoves me to give you some brief impressions of my observations on this most interesting subject.

A well-known maxim in education is to proceed from the known to the unknown. Relating this to my subject today, I shall first traverse some ground that will be known already to most of you, namely, agricultural developments in New Zealand over the last 25 years. We take for granted the changes that have occurred, but it is of interest to list some. The almost complete disappearance of the horse and the general mechanisation of farming are perhaps the most obvious changes. Another factor, partly a consequence of mechanisation, but also due to the application of scientific knowledge and new techniques, is the outstanding increase in output from each person engaged today in farming as compared with 25 years ago. Scientists have provided us with strains of grass which will grow many more blades than could be expected formerly from each plant. Science, in its discovery of trace elements, has provided us with the answer to many of the problems with which we had to contend in certain parts of the country.

Agricultural education with its emphasis on science, has contributed in large measure to the increasing productivity of our farms. Farming practices, I am pleased to say, are no longer dictated by what "our grandfathers did," nor do our farmers harbour prejudices against "new-fangled farming techniques." Increasing numbers of their sons are attending agricultural colleges such as Lincoln, not because it is the "correct" thing to do, but from a sincere conviction that they will be more complete and successful farmers through having undertaken the courses provided. From the nation's angle, the investment in agricultural education has yielded a high return in the form of increased output.

Aerial topdressing which has operated only since 1950 has meant an almost revolutionary advance for the sheep industry. The application of fertilisers on huge areas formerly unable to be done has made possible a large increase in carrying capacity. Sheep numbers since 1950 have increased by about 35 per cent, while over the same period the numbers of beef cattle have been increased substantially. Fencing has had to be extended, and although no statistics of mileage of farm fencing is available, there is no doubt that it has increased by several hundred per cent. As an aid to better techniques of stock management, fencing is assuming greater importance.

In a nutshell, it could be said that, over the 25 years, we have approximately doubled our wool and lamb production and increased
the output of butterfat by about 50 per cent. Better farming techniques, aided by science, have made possible these increases. The most spectacular contributions of the scientist have been the discovery of the significance of cobalt in animal health enabling the opening up of pumice lands of the Central Plateau of the North Island; the development of vaccines and other materials that prevent disease in stock; the recognition of the need for phosphate and mineral topdressing of pastures; herd testing and progeny testing; the inoculation of legume seeds; the selection of disease-resistant forage crops; artificial breeding; and the adoption of aircraft to agriculture. These have all made a contribution to the increased output.

During the period, income stabilisation schemes for some of the main farm products have been introduced. In 1936 the dairy industry commenced operating under the so-called "Guaranteed Price" Scheme. Since then the original scheme has been amended considerably, but it is unlikely that the industry will ever return to its pre-1936 arrangements. As a result of the realisation of the stocks of wool accumulated during World War II, the wool industry established a reserve fund for the operation of a floor-price scheme. The meat industry accumulated a large reserve fund through its operations under the bulk-purchase agreements for the war and post-war period. This has made possible a floor-price scheme for meat producers by which they are assured of a minimum price for the meat they produce. Of the three schemes, the wool and meat ones determine the minimum price, while the dairy scheme controls both the minimum and maximum price paid to producers. In all cases the schemes represent a facility not available to producers 25 years ago. So much for New Zealand agriculture.

What of farming in the United Kingdom? In the depression of the early thirties, agriculture suffered severely and the Government introduced legislation to assist it financially. In the early part of World War II, agricultural supplies from the continent of Europe ceased, and increasing difficulty was encountered transporting supplies from other normal suppliers, including New Zealand. Increased emphasis was thus placed on the need for more home-produced supplies, and to achieve these the Government made a large increase in subsidies and grants to agriculture.

In the post-war years, this aid was made permanent in the Agriculture Act of 1947. It was supported by both parties and aimed at promoting "a stable and efficient agricultural industry capable of producing such part of the Nation's food as in the national interest it is desirable to produce in the United Kingdom, and of producing it at minimum prices consistently with proper remuneration and living conditions for farmers and workers in agriculture."

Agricultural production in the United Kingdom is now 60 per cent greater than pre-war, and the Government provides in the form of grants and subsidies about 15/- out of every £ of the net income of the British farmer. Each year the Government reviews its aid to agriculture, and in the discussions the farmers are represented by their Union, the National Farmers' Union of England and Wales, Scotland and Northern Ireland. The N.F.U. has its own team of economic experts who argue the farmers' case with the economists of the Ministry of Agriculture and Fisheries. The fact that the farmers speak with one voice has meant that the N.F.U. has become a very powerful force to be reckoned with. For instance, in 1957 it was instrumental in persuading the Government to pass legislation which limits until 1962 the extent by which farm guarantees may be reduced in any one year or three-year period. The N.F.U. believed that such a measure was essential if farmers were to make longer-
term production plans. It has also succeeded in securing many other measures in the interests of farmers, although, of course, the Government does not always heed its clamours.

Support to Agriculture in the United Kingdom takes many forms, and a complete description would require much longer than the time I have available today. In general, there are direct grants for the production of certain products, plus a guaranteed minimum market price, grants for the building of farm houses, special grants to assist small farmers, subsidies on fertiliser and lime, grants for tree planting and scrub clearing, subsidies on raising hill sheep, cows and cattle, subsidies on calves and general financial assistance for improvement schemes of varied types. The price guarantees, as distinct from the subsidies and grants, are related to ruling market prices. The total cost varies, therefore, from season to season. For instance, in the 1958/59 season the total cost to the Government was reduced from an estimated £284 million to £248 million, mainly through higher market prices for beef. But even at this reduced figure the cost is still a high one to taxpayers in the United Kingdom.

In the United States, there is Government support to most farm products. The main exception is meat. The support originated at the time of World War I, and was increased to assist farmers during the slump of the early 30's. The important determinant of support assistance is the "Parity" concept. This, briefly, is the attempt to ensure that what the farmer receives for his products bears a "fair" relationship to what it costs him to produce. A base period, usually 1914/18, was used and changes measured from that point. During World II the support was intensified, and, in general, became a permanent part of post-war U.S. agriculture. This boost to agriculture has brought forth production considerably in excess of what markets will consume at the prices charged. As a result, the U.S. Government, the Commodity Credit Corporation, has had the task of disposing of the surplus quantities of grain and dairy products. Within the United States it has fostered schemes such as school lunch programmes which utilised some of these stocks. But large stocks still remained and the U.S. Government has adopted schemes, the main one being Public Law 480, by which surplus commodities could either be donated or sold on special terms to other countries, particularly the under-developed ones.

American agriculture has increased its productivity through the aid of mechanisation and the application of new techniques. Today's farm worker can produce in one hour what it took two hours in 1940 and three hours in 1910 to produce. In arable farming and feeding methods it probably leads the world. It has been estimated that the current U.S. harvest is a record, 118 per cent of the 1947/49 average —11 per cent above the previous record. This, in turn, will create problems for the U.S. Government and, of course, producers in other countries.

Legislation in World War II calling for rigid farm supports at 90 per cent of parity expired at the end of 1948. But a return to a lower support was repeatedly postponed and rigid supports were not lifted until the Agriculture Act of 1954. It provided flexible supports ranging from 82 to 90 per cent of parity on five major crops in 1955, with the floor, supply and demand conditions warranting, dropping to 75 per cent of parity beginning in 1956. However supports did not drop to the 75 per cent level until 1958—and then for only two crops (wheat and rice). Even the 75 per cent level is considered too high to encourage adjustments needed in agriculture. Aware of the need for lower support, President Eisenhower asked Congress in 1958 to lower the support floor on basic crops to 60 per cent of parity, and to abolish escalator clauses that require
supports to be raised as surpluses are reduced. Congress rejected this request, and passed a bill freezing price supports on 1958 crops at the previous year's higher level. The President vetoed this bill and the final outcome was the Agricultural Act of 1958, based on the principle that greater flexibility in price supports will lead to expanded markets. Although it was a compromise measure, the new law moved towards greater flexibility.

A recent development in U.S. agriculture is the trend towards what is called "Vertical Integration". This occurs when more than one of the stages of producing and marketing a commodity are controlled by the same individual or firm. It can best be illustrated by citing the broiler industry. Broiler producers sign contracts with a feed dealer or manufacturer. The latter owns and supplies the feed usually on credit. He owns the hatcheries which produce the baby chicks, or contracts with hatchery owners to produce them; these are supplied to the producers usually on credit. The dealer may sell the finished birds to a processing firm, or contract with a processor to slaughter and prepare them for the market and then sell them directly to the retailer. This is but one of many variations of vertical integration in the broiler industry.

The effects of such a system are numerous. The mass-production techniques increase the output greatly and reduce the market prices. Farm groups claim that the disadvantages to farmers of such a system is that "off-farm" interests gain the highest profits at the expense of the farmer, and that farmers tend to become controlled by the processors. The main remedy advanced to counter these threats has been an extension of farmer activity in production and marketing.

The U.S. broiler industry is now producing nearly 2,000 million birds—more than three times as many as in 1950. In the United Kingdom this season about 50 million broilers will be produced. To meat-exporting countries such as New Zealand these trends cannot be ignored.

What of Canada? Last year new legislation was enacted replacing the Agricultural Prices Support Act which had operated since 1944. The new Act, the Agricultural Stabilisation Act, named nine commodities for which support or "prescribed" prices must be established each year. These "named commodities" are cattle, hogs and sheep, butter, cheese and eggs, and wheat, oats and barley not produced in the area covered by the Canadian Wheat Board Act. In addition, it provides that any other product of agriculture may be supported. These latter are called "designated" products.

Each year a basic price is to be established for each of the commodities to which the Act applies. Such "basic prices" are the average prices of the commodities involved for the previous ten years. For the nine "named" commodities, the support or prescribed price must be at least 80 per cent of the basic price. But there is no minimum percentage for the "designated" commodities. There are three ways of implementing the support prices on either the named or designated commodities. Firstly, there may be outright purchase by the Government. Secondly, there may be a deficiency payment to cover any differences between the prescribed price and the actual market price. Thirdly, there may be a fixed payment to producers where such seems more practical than either of the other two methods. Under the Act, there is provision for support prices for such commodities as wool, skimmed milk, asparagus, tomatoes, honey, raspberries, apricots, sugar beet, soya beans, potatoes and turkeys. As in the United States, the support schemes have led to surpluses in the hands of the Government.
In European countries, agriculture is founded on the small family unit, and to survive, many have to be supported by their Governments. The support schemes adopted vary in detail but most include the type which, in order to restrict Government contribution, places a ban on imports of commodities where the retail price is below a stipulated minimum. This is in direct contrast to the United Kingdom scheme which supports the farmers directly, allows the market price to find its own level, and does not ban imports of the farm commodities concerned. Butter is an instance of a commodity whose retail price on the Continent has been kept up at too high a minimum level, and as a consequence consumption has in some cases been seriously reduced. In turn, the surplus quantities of domestically-produced subsidised butter have been exported to the only free market, the United Kingdom. This is a case of the taxpayers of the continental countries concerned subsidising the consumers in the United Kingdom!

I have given you a racy survey of some aspects of present-day world agriculture. The support policies being adopted have created immense problems to international agriculture. What of the solution to these problems?

At the Tenth International Conference of Agricultural Economists held last year, Professor M. A. Lewis of the University of Manchester commented as follows:

"As far as the agricultural economist is concerned the main remedy for the farmer's ills must always be to have fewer farmers. The speed with which the proportion must contract depends entirely upon the rate of growth of productivity per person in agriculture. The required contraction is greater in rich than in poor countries..."

The U.S. economist, Dr. DeGraff, of Cornell University, in a speech before the American Bankers' Association last September, said:

"Probably no acceptable level of price supports could be devised that would not be an incentive level to such a leadership group, even though low enough to be attacked politically as disastrous support levels for less efficient farmers. This is the very essence of the reason that price supports will never provide a satisfactory solution to what is widely looked on as the income problem of agriculture. Support levels that would make less-efficient farmers profitable will always be so high as to force production controls on the leadership group. In other words, support prices will perpetuate inefficient production and will also force inefficiencies on the leadership groups which would be more efficient with no price support at all."

The establishment of the European Common Market could have important implications for agriculture. Because of the special problems of agriculture the Treaty of Rome in which the Common Market scheme was formulated, has provided for additional arrangements in the agricultural sector.

One of the aims of integrating the economies of the Six was to achieve benefits from specialisation. If this principle were extended to agriculture, increased trade could result for those agricultural producing countries who are not members of the Community. As yet, however, it is too early to make any deductions as to the effect on agriculture of the setting up of the Common Market. The 1958 Annual Conference of I.F.A.P. felt that the resolutions of the Six on their agricultural policy must be interpreted to cover a general expansion of trade, recognising, however, that the special links between the Six will probably result in a relatively bigger increase in trade within the Community itself.

It would now be a fair question to ask—"What on the International level (including I.F.A.P.) has been done to find solutions to some of the problems I have mentioned to you?"
At the International Conference held at Hot Springs, New Georgia, in 1945, it was decided to set in train a co-ordinated international effort to secure a large expansion of agricultural production—especially of the protective foods—to meet the nutritional requirements of growing populations in the post-war world. This was to be accomplished, mainly, by the setting up and staffing of an international organisation (F.A.D.) which would (a) survey and analyse the world agricultural (especially food) situation, and (b) act as a forum through which Governments could co-ordinate their agricultural policies. It is important to note that the possibility of getting too much production and the possible need for international cooperation in bringing about a reduction of production in certain cases, were completely ignored.

By 1953 it was apparent that “surpluses” were developing in a number of commodities, but the Seventh Conference of F.A.O., instead of looking certain “facts of life” squarely in the face and dealing with them as best it could, adopted the principle of “Selective Expansion”. There were probably three reasons why the Conference did not take a more positive attitude towards solving the problem. (a) Governments were only lukewarm on agreements and their implication of producer control; (b) there was not general awareness that the economically advanced countries were capable of producing far more of the basic foods than the populations of these countries could consume—and even more than could be disposed of on a bargain table basis in the under-developed countries, and (c) there was not a general recognition of the fact that there are two agricultural worlds within the Free World. One world is the modern, highly-mechanised agriculture of the economically advanced countries, and the other consists of the archaic agriculture of the under-developed countries. In the former, except in isolated instances and time of war, consumers do not lack food. In the latter, agricultural production has tended to fall short of meeting basic human needs. A principle of agricultural production designed to meet the situation in these two “worlds” had little meaning for either.

There is little evidence to show that the “principle of selective expansion” has been taken seriously by Governments in the formulation and administration of national agricultural programmes which unfortunately have been dictated by national considerations. Little if any attention has been paid to the full implications of the words “selective expansion”. As a result some surplus situations (wheat is a classic example), have become chronic, and others threaten to arise from time to time. The I.F.A.P. Commodity Consultant, Mr L. A. Wheeler, has summed up what, in his opinion, is required as follows:

“What is needed—in the case of a chronic lack of balance between export production potentialities and actual, realistic import requirements—is a concerted international effort to reduce production in the exporting countries and to discourage further expansion in the importing countries. Such concerted action can be obtained, if at all, only through international commodity agreements where governments undertake definite and specific commitments. Consultations on the basis of general principles cannot take their place.”

Since its inception in 1946, the International Federation of Agricultural Producers (I.F.A.P.), the federation of national farmers’ and agricultural co-operative organisations the world over, has concerned itself with the problems of world agriculture. I.F.A.P. is the voice of the farmer in international affairs, and its main functions are to develop understanding of world problems and how they affect the agricultural producers of the world, and to lay the co-ordinated views of the national organisations represented before any appro-
priate international body, principally the Food and Agricultural Organisation of the United Nations (F.A.O.).

I.F.A.P. strongly endorsed the principles laid down by F.A.O. that surpluses should be used to build up national reserves. It also recommended the setting up of an international agency to handle such surpluses on a multilateral basis. At the 1958 Annual Conference it was affirmed that in cases like wheat and sugar where there are chronic imbalances in supply and demand, there is the greatest need for international commodity agreements designed to achieve price stability, and also a need for effective international consultation concerning surplus disposal. In the case of temporary surpluses—especially of perishable or semi-perishable commodities such as dairy products—I.F.A.P. considered there should be more effective intergovernmental consultation.

Since the 1958 Annual I.F.A.P. Conference a new international wheat agreement has been signed. The agreement is a distinct improvement on the one it supersedes. Its objectives include the promotion of expanded trade and the securing of the freest possible flow of trade in the interests of all member countries, the encouragement of the use and consumption of wheat, and the furtherance of international co-operation generally concerning wheat problems.

At the 1958 Conference it was also resolved that an extension of the International Sugar Agreement was urgently required. Since then 40 nations have adopted a new agreement, effective as from January, 1959. The new agreement provides for larger export quotas and slightly different price stabilisation machinery.

Concerning butter, I.F.A.P. has, I believe, had considerable success in influencing governments concerned to adopt policies that will lead to a reduction in the price to the consumer, and hence increased consumption. The 1958 Conference spent considerable time deliberating on the various aspects of the problem, and it made detailed recommendations which, if further adopted, could increase substantially the level of international trade of butter.

The question has often been posed of the possible effect on the problems I have mentioned if the Soviet Union increased its participation in international agricultural trade. Past experiences of western nations trading with Russia have not always been happy ones. But I suggest that the Free World cannot ignore the likely effect of its surplus production on the so-called under-developed countries. If as a result of, say, surplus disposal of United States grain on a market which is the usual one for the grain produced by one of the under-developed countries, then the latter may have no recourse but to sell it to one of the Iron Curtain countries. This, of course, means that it will purchase its requirements, usually industrial goods, from the Communist country, and thereby become associated more closely economically. This in turn usually leads to a closer association politically. Unfortunately instances have already occurred where this process has taken place. It is certainly not in the long-term interests of the democratic nations of the west. But if the western nations do not adopt improved policies for disposal of their surplus production, then more of the under-developed countries may be driven economically, and ultimately politically, into the Iron Curtain camp.

In so far as New Zealand is concerned, the increasing protection given agriculture both in Europe, America and elsewhere, has reduced substantially its chances of expanding overseas markets. The United Kingdom market, where New Zealand produce has unrestricted right of entry, has recently been referred to by the President of the National Farmers’ Union. Sir James Turner (now Lord Netherthorpe), speaking at the Annual Meeting of the Union said:
"We believe that the U.K. Government should help to promote machinery for periodic inter-governmental meetings in order to keep trade conditions under constant review, and to be able to take ad hoc action when circumstances justify. Indeed, during the emergency over butter and dairy products, that machinery was most effectively used and proved its usefulness. . . . But if we are going to approach the whole problem of food on the world front it is not only on the international front that we have to look, we have to look at the interpretation of policy on the home front too. Here, as far as the United Kingdom is concerned, we believe it imperative that there should be some effective co-ordination of imports into this country, compatible though they would have to be with international agreement."

It has been suggested that the above was a polite way of suggesting the imposition of quotas on agricultural produce entering the United Kingdom. Incidentally, at present the Dairy Section of Federated Farmers and the N.Z. Dairy Board are considering detailed proposals made by the N.F.U. for the establishment of an International Butter Agreement. Its two main objectives are stated to be to stabilise butter prices within an agreed range and to protect importers against an excessive increase in price and exporters against an excessive fall.

So much for some of the present problems facing agriculture throughout the world. Their solution at times may seem impossible, and many of you probably consider that attempts by international organisations such as F.A.O. and I.F.A.P. will achieve nothing really effective. Delegates to these organisations may seem to do nothing but pass pious resolutions which are ignored by those to whom they are aimed. The Secretary-General of I.F.A.P., Mr Roger Savary, referred recently to what he called the "Seamy Side" of international conferences. He said that it was no exaggeration to say that probably three-fifths of the time at international conferences was devoted to skirmishes amongst delegates on procedure, another fifth to courteous platitudes, and still another fifth to carefully written out "national" statements. The latter are ways of digging in one's heels and entrenching oneself. It does not seem to matter at all that there is no sixth-fifth left to try and do what an international meeting is supposed to do, namely, work out an agreement between governments who were disagreed at the start. Mr Savary asks, how can anyone still recommend more international consultation, how can anyone still advocate more meetings? He replies as follows:

"For the same reason that makes the citizen vote for politicians with a disappointing record, the faithful pray to gods who overlook their pleas, the betrayed warrior to fight to the end, and the farmers sow seed again after drought. Because nothing can be worse than life without hope. If international co-operation is undermined consciously or unconsciously by many of those who should make a success of it, there is nothing else to do but try and try again. International co-operation is the only way to a better world. No disabused assessment of its seamy side should deter us from following it".

Is there nothing concrete we in New Zealand can do about these things? The great threat to the free world today is from the iron curtain countries.

At the moment we have two definite trading blocs in the world—Communist and European.

In the European theatre we have the present attempt to improve trade through the Common Market. Despite long negotiations, Britain's proposals for a European free-trade area have not yet eventuated.
I.F.A.P.'s objective is naturally real international co-operation. But within I.F.A.P., at the moment, we have regional meetings to reconcile difficulties between neighbours, and paving the way to the wider objective.

In Europe we have one such regional committee presided over by Mr Fred Scott of England.

In North America we have a similar regional committee with the same aims and objectives.

Mr James Patton, present President of I.F.A.P., believes in this regional approach to farm problems and has suggested that we in New Zealand should consider this approach also.

Could Canada, U.S.A., New Zealand and, if possible, Australia, discuss such an arrangement with a view first of all, to improving our own trading position, but with the ultimate object of eventually extending freedom of world trade? This would be well worth considering.

From what I have said you will realise the extent of moves already made, and similar action in the Pacific area would make a contribution which could ultimately link up with the United Kingdom and Europe.

We must remember that it is in New Zealand's interests to endeavour to influence the countries which place a fence round their economies. Their action is a serious obstacle to our long-term aim—real International Co-operation.
SOME RECENT DEVELOPMENTS IN SHEEP MANAGEMENT ON NORTH ISLAND HILL COUNTRY

E. A. Clarke, Ruakura Research Station, Hamilton.

Factual information relating to hill farming is very inadequate and often lacking on many aspects of this subject. Hill-country farming practice, too, is subject to much wider variation than fat-lamb farming because of extreme contrasts in such things as soil type, climate, contour, elevation and aspect, even on relatively adjacent farms. Also, the products of hill-country farming tend to be more varied and proximity of good markets for particular products will often be reflected in farm policy.

Hill-country farming, however, is essentially grassland farming, and although some hill farms may have useful areas of cropping land, in the main grass alone provides the needs of the animals throughout the entire year. Hay may be bought in some cases as a winter supplement for cattle or as a precaution against facial eczema in the ewes in the autumn.

Good prices for farm products over the past decade have resulted in such practices as aerial topdressing, oversowing and subdivision changing much of our hill country out of all recognition. In many cases what was store country is now breeding country and some even fattening country. Where a molybdenum response is obtained as for example on many soils derived from greywacke, the increase in pasture production has sometimes leaped by 50 per cent or more in one season. Of great importance too, is the better spread of production of the improved pastures into the drier, late-summer and early-autumn period, and into the winter. Spring growth commences earlier and indeed in many cases worthwhile winter pasture-production greatly assists in the problem of equating animal needs throughout the year to seasonal pasture-production.

The real basic problem in hill farming is that of combining a dual role in the animals. They are the units of production and also usually the only implements of pasture management and control of second growth. In the higher rainfall areas in particular the efficient control of second growth is the key to high production.

In the stocking of the hill farm, the maximum number of ewes should be the aim since these are the most productive stock and can be managed to be efficient hill-country implements. Cattle are the traditional implements, but again females are the more profitable stock and can play an increasingly important part in pasture and weed control as the country improves.

The maximum number of breeding stock and the minimum of dry stock mean fewer mouths to winter and the maximum mouths to utilise and control the spring flush of feed and to control the summer fern regeneration. The grazing of stock to achieve this follows—as much of the year as possible a mob-grazing system with most of the stock—preferential treatment being given to the young stock and to the breeding stock prior to parturition and during lactation.

Ewe Management

To achieve high production per acre on hill country as on fat-lamb country, necessitates high ewe-carrying capacity. Production per ewe is less important than production per acre.

Trials on the Ruakura Hill Station, contrasting a flock well managed throughout the year and always well fed with a genetically
identical flock farmed under a system of chronic overstocking at all times, reveal that the overstocking system decreases production on a ewe basis by about 15 per cent in wool production, by up to 10 per cent in lambing percentage, and by about 10 to 12½ per cent in lamb weaning-weight. The data do not yet permit accurate conversion of these differences to a per-acre basis but a conservative estimate of the relative stocking rates under the two systems would be three for the overstocking system to about two for the other. There can be no doubt which system yields the greater return per acre. One would not, however, advocate an extreme overstocking system which leaves one at the mercy of unfavourable seasons when it becomes necessary to sell breeding stock in poor condition on an unfavourable market. It is clear, however, that in the interests of maximum production per acre one should err in the direction of overstocking rather than understocking. Maximum carrying capacity per acre is also in the interests of full utilisation of pasture and control of pastures and weeds during periods of rapid growth.

One should aim, however, at going into the summer dry spell with a good leafy cover on well-controlled pastures. This greatly reduces the impact of the dry spell on pasture production. As the sward improves under topdressing and controlled grazing with better species replacing danthonia, browntop and weeds, the normal dry spell ceases to be a hazard, but is regarded rather as an opportunity to catch up on pasture control on the less-developed areas. Early weaning, as will be shown later, contributes greatly to these objectives.

There is, as yet, far from enough factual information on ewe management on hill country during tupping. Flushing often depends on the season although it can be under considerable management control where mob grazing is practised; and where flushing is aimed at, preparations for tupping should begin about three weeks before the rams are turned out. Mob grazing should be continued but complete utilisation is not now aimed at since a substantial live-weight increase should be the objective. It remains to be shown, however, if much is achieved where the ewes are first pulled down in condition in order to be flushed before the rams are turned out. Good body weight at tupping has been shown by Wallace to be conducive to better lambing percentages.

In the case of good development of two-tooth ewes, the objective since weaning should probably still be the aim, so that they are grazed as a separate flock and are best tupped separately. It has been shown by Inkster that the two-tooth ewe has a weak heat and one of short duration and does not seek the ram as does the older ewe. These young ewes should be grazed in the smaller and cleaner paddocks and, if possible, mustered daily to facilitate the work of the rams. This can increase the lambing percentage of these ewes by as much as 15 per cent or over. Interim results from shearing trials clearly indicate a worthwhile increase in lambing percentage of two-tooth ewes shorn just prior to tupping. Likewise good rearing through their first year has a marked effect on two-tooth lambing results. Good body weight at tupping has been shown by Wallace to be conducive to better lambing percentages.

Few ewes commence their breeding season before mid-March, so that the rams are put out after this date. The effect on lambing percentage of delayed mating on hill country where twinning is low is still to be determined. All rams should be turned out, since the majority of ewes (up to 80 per cent) are mated in this period. There is little advantage in leaving the rams out longer than eight to ten weeks. Our results indicate that prolonging the mating period up to 14 and 15 weeks results in only a small increase (about two per
cent) in the lambing percentage and these few extra late lambs are a complication in the policy of grazing management, especially where early weaning is practised.

The minimum number of rams necessary is yet to be determined. The traditional three per cent is still used by many. In our limited experience however, one sound and vigorous mature ram per 100 ewes has been ample under quite difficult hill conditions. Observations made by Lambourne at Ruakura indicate that the two-tooth ram, although vigorous, shows a degree of inexperience in his work, and for this reason two-tooth rams would not be used on two-tooth ewes.

Flushing should be continued for two to three weeks into the tupping period and then the grazing management is tightened. With the rams removed, the mobs can be combined since a well-reared two-tooth winters as well as a mature ewe. From the end of about April onwards grazing management aims at spelling as many paddocks as possible to provide early spring feed. To achieve a worthwhile result the ewes must be done hard on the tougher paddocks leaving the better ones to grow pre-lambing and lambing feed.

The aim is to conserve feed on at least one third of the farm. A maintenance or slightly sub-maintenance ration for the ewes from mid-April until three to four weeks before lambing commences does no harm but from this time onwards a rising plane of nutrition is desirable and a safe precaution against sleepy sickness.

It is common practice, about three weeks before lambing commences to draft the ewes into early and late lambing mobs, the former set stocked on the best of the saved feed and the latter spread out more thinly over the poorer paddocks. Set stocking is then continued until weaning. On hill country, however, where mob stocking is practised, the ewes soon learn to shift themselves when the gate is opened. Under these conditions, at lambing time ewes can be rotated through a series of paddocks, leaving in each the newly-lambed ewes. In this way, as on a fat-lamb farm, as many lambing groups as the paddocks available permit may be sorted out to greatly facilitate shepherding, docking, vaccination and stock management. On many hill farms today pasture improvement has reached the stage where vaccination against pulpy kidney (enterotoxaemia) is a necessity.

Some culling is best done at lambing and docking. Coloured plastic tags are ideal for marking ewes for subsequent easy recognition. All culls observed may be given, for example, a red tag. These culls should include those with bearing trouble since our most recent results strongly indicate an inherited pre-disposition to the disease. Also subsequent breeding performance is so poor and recurrence of the disease so frequent that they are an added burden on a busy shepherd. After immediate remedial treatment such ewes are best drafted out of the flock for easier observation and grazing management should be hard.

At docking, dry ewes are readily picked out and can be tagged with, say, a blue tag. Next year any dry again will have the blue tag replaced by a red indicating a cull. Those marked as dry would include not only those which had not conceived but also those which had aborted early and which are indistinguishable from the former. Over a period of some eight years it is our finding that only about three per cent of ewes, mainly four-tooths, come into the twice-dry category (i.e. dry for two consecutive seasons).

Our infertility problem is clearly one of temporary infertility. Of the 30 ewes per 1000 which are twice dry, less than half are sterile and quite incapable of breeding, usually due to physical abnormality. The remainder are fertile but probably mainly shy breeders, although a few might be classified as just unlucky.
Weaning and shearing of ewes and lambs can well be carried out in late November when the lambs may be at an average age of only 12 weeks. At shearing time culls can be removed; included in these would be a small proportion of ewes in very poor condition. Our records show that these few ewes are seldom twin-bearers and they can well be spared from the flock. Following shearing, the ewes are run as one mob.

It is now that fern control can be seriously tackled by concentrating the maximum number of mouths and hooves on each of the paddocks concerned in quick succession. Mob grazing is the most effective technique and imposes the least hardships on the stock because with such a large mob, the paddock changes are quick and the flush is not followed by a slow, prolonged famine as is the case with small mobs, if worthwhile fern control is to be achieved. The older dry cattle are best used to deal with tall fern and large areas of this are best burned in the autumn and oversown. Ewes can deal efficiently with the new fronds of bracken fern, when it is still in the tender stage which is the stage at which fern regrowth is most effectively controlled.

Hogget Management

Throughout October and early November in an average season, pasture production is outstripping animal needs so that areas can be taken out of use and shut up to provide early weaning-feed. In a good season lambs weaned in January may be up to a maximum of four pounds heavier than lambs weaned in November owing to the milk available over the extra five to six weeks. In a poor season lambs weaned early, on spelled paddocks if possible, are likely to be four pounds heavier than late-weaned lambs. The little extra milk available to the latter in this case is more than offset by ewe competition with the unweaned lamb for available grass.

The advantage of early weaning however does not lie in any extra weight available, which in any case is of small order, but in the flexibility of management which is available in the case of both pasture and stock. Weaning in January is too late for example for effective fern control with ewes.

After shearing, the lambs can be given the pick of the pastures ahead of all other stock, and the wether lambs disposed of at the lamb fairs. At the same time, the ewe lambs are lightly culled and these sold also. Our data show that differences in live-weight between lambs at weaning time are largely maintained throughout their first year and that the smaller ewe-lambs make the smaller two-tooth ewes. Further, although the number of twins is not high, and seldom exceeds 16 per cent of the lambs, these tend to be of average live-weight. Culling the few smallest lambs therefore does not constitute selection against twins as is commonly believed.

Unlike the problem in the South Island, ill-thrift in lambs is seldom encountered in the North Island before early autumn, although intestinal parasitism can be a serious problem in a wet summer. In the past season, however, serious ill-thrift in lambs was encountered in many areas, mainly in the pumice belt in the late spring and summer. These, in most cases, responded markedly to treatment with selenium salts as did similar outbreaks in parts of the South Island. It is still true to say, however, that on North Island hill country, hogget ill-thrift is an autumn problem.

Throughout January and February the hoggets cause no concern in an average season. They can be rotated around the best pastures ahead of all other stock and maximum live weight gains of up to three to four pounds per week should be the aim. If the season is dry, pastures over the entire farm soon become short and well controlled, a state of affairs conducive to a rapid response to rain, particu-
larly if topdressing has been completed. It is this rapidly-grown, fresh autumn feed that seems to be a cause of hogget ill-thrift. If hoggets commence to "go back" on what is normally regarded as plentiful, well-controlled pasture, some alternative is essential. This cannot be produced overnight, and it is too late to consider its provision only when it is needed. Early in December, therefore, about 80 to 100 acres will be well prepared by cattle and shut up to provide mature grass for about 500 hoggets, if and when it is needed in the autumn. It will not be used until it is needed and then as sparingly as possible. By set stocking it will provide for the number of hoggets for up to two months or more, and a weekly live-weight gain of up to two pounds can be expected. Crops as well as pasture can likewise be immature for hoggets if not sown early.

From June onwards the only problem is the provision of sufficient feed to keep the hoggets growing as well as possible. Hoggets well-reared through their first winter will give a much better lambing percentage as two-tooth ewes than hoggets poorly reared, even though by mating time their weights are similar. The difference in lambing percentage can be as much as 12 to 15 per cent.

**Rams**

The recent discovery by Buddle and his co-workers at Wallaceville of the main cause of epididymitis in rams, and the provision of a highly-efficient vaccine against *Brucella ovis* have paved the way to the elimination of a serious cause of infertility in both rams and ewes. Edgar and Inkster of Ruakura have provided a rapid and simple method of semen collection, enabling an assessment of semen quality to be made in the field as well as providing a semen sample for laboratory examination for the presence of *Brucella ovis*. Examination of the semen of many hundreds of rams over the past three seasons has shown that early in the breeding season many rams are sterile or of very low fertility. In some flocks, nearly half the rams normally used have been in this category, and although as the season advances many rams improve, there are many which do not. Farmers under the impression that they have been using three per cent of rams have in many cases been getting real use from considerably less. Further, each inefficient ram is screening a proportion of ewes from the fertile rams. Lambourne at Ruakura found that in a flock of rams there is developed a fairly-clear-cut ranking order. If top-ranking or "boss" rams consist of many of low fertility, these can be of considerable disservice during the tupping period.

Of recent years much has been heard of the importance of face cover in sheep. Trials in New Zealand and overseas with many breeds have clearly shown that the more-open-faced sheep within a flock are more productive. Our results at Ruakura Hill Station indicate that on hill country where feed supplies are not always optimal, the effect of face cover is most marked in the two-tooth ewes. The more-open-faced produce up to 50 per cent more weight of lamb weaned per 100 ewes mated than the more-woolly-faced. The intermediate types give intermediate production. This increased production is the summation of wool, lambs born, greater survival, heavier birth weight, and heavier weaning weight. In older ewes however the effect is small. On lowland country, where the level of nutrition permits the fuller expression of twinning potential, the effect of face cover is expressed, not in markedly better performance of the two-tooth ewes, but in higher twinning-rate in the open-faced mature ewes. The open-faced sheep tend to be somewhat bigger and just as good producers of wool as the woolly-faced sheep.

It is to be emphasised that what has been said above refers to the situation obtaining within a flock and does not necessarily mean

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that a predominantly-woolly-faced flock must be of lower fertility than a predominantly-open-faced flock. Recent findings by Inkster suggest that in selecting rams, the ideal from the point of view of face cover would be to select open-faced rams from a flock of high fertility. It need hardly be stated that at present such rams are not easy to locate.

Cattle

Time will permit only brief mention of our philosophy on cattle management. It has already been stated that a decrease in numbers of heavy cattle and an increase in cows and young stock is envisaged on North Island hill country, particularly where the initial breaking in has been largely achieved. It is believed too that much initial breaking-in of the country is more cheaply achieved by fire and oversowing than by hammering cattle.

To use cows to maximum advantage requires a more systematised policy than is generally practised. At the Hill Station the bulls are put out in November and removed at the end of January when the calves are also weaned at an average age of four and a half months. Trials contrasting early and late weaning have shown that the difference between calves weaned in January and those weaned in May may reach a maximum of 40 to 50 pounds at the end of the first year but that by mating time at two years of age this difference has practically disappeared. In most years the maximum has not exceeded 15 to 20 pounds, and it is confidently expected that, as the country further improves, the difference will disappear and possibly early-weaned calves may be superior.

Early weaning means that the cows are unencumbered and available for work from February to late June and over this period surplus condition may be worked off them without any risk. Over July they should be brought up in condition, if low, or held in good condition before calving. For this purpose hay and/or crop is advantageous and autumn-saved pasture is also used. Hay brought for this purpose is used to further the crushing and seeding of dirty sidings and burns of standing manuka which ensures maximum returns for money spent on hay.

In this brief outline, the endeavour has been made to indicate some tested principles of flock and herd management and of integrated stock and pasture management on our hill country.

In closing, may I epitomise our philosophy by repeating again that the animals are the units of production but also the hill-country implements and these two roles must be integrated in the interest of maximum production per acre.

Q.: From your trials, what is the lambing percentage from dry ewes that have been tagged with a blue tag the first year and second-year dry ewes tagged with red?

Mr Clarke: The number of these over eight years has not exceeded 30 per thousand. When these ewes are tupped intensively under suitable conditions, 50 to 60 per cent are got in lamb. The remaining 40 to 50 per cent are examined to find out why they did not conceive. In the majority of cases there is a physical abnormality. Frequently the reproductory tract is juvenile; sometimes the ovaries are very tiny and non-functional; or, may be, there is an infection in the fallopian tubes leading from the ovary to the uterus, causing a lesion which is sufficient to render the animal sterile.

Q.: Have you any record of the lambing percentages of such dry ewes against the whole flock?

A.: Yes; the majority of these sheep are two-tooths which have been a little on the small side. In subsequent years they have bred
fairly well. Lambing percentages tend to be higher in the following year.

Q.: Re your system of culling ewe lambs. Do you cull to keep the twins and how?
A.: Actually, we have detailed records of every sheep on the place so there is no real problem there. In culling the tail-end ewe lambs about weaning or shearing time, you are not culling twins as they tend to be about the average of the flock. In hill country, twins seldom exceed 20 per cent. The majority of the tail-end lambs are the late-born single lambs, so I put forward the recommendation that one can simply cull the tail-enders and have no fear of culling many twins.

Q.: In a flock of two thousand ewes on hill country, what proportion of ewe hoggets would you put back into the flock; and would you run Romney ewes with Romney rams?
A.: The general rule in the North Island is for ewes to be kept on the hill for four years and then sold as five-year-olds to fat-lamb producers. Where we have a lambing percentage of 90 we would be bringing in 460 ewe lambs less a few we cull—420 to 430. The majority of these would be wintered. There may be a loss of two to three per cent of the ewe hoggets. (In some areas it may be five to 20 per cent.) The number required for stock replacements is 28 to 30 per cent of the flock. For one thousand ewes, therefore, three hundred ewe hoggets would be replaced. You can thus cull about 120 and still have enough replacements. I have been referring to Romney rams, but I recommend the Border Leicester-Romney cross which get a higher percentage reaching a figure of 120 to 130 per cent. The usual figure in North Island hill country is 90 per cent or less.

Q.: What effect would doing ewes harder after tupping until a month or so before lambing have on the quality and amount of wool grown?
A.: That practice is advocated on hill country where there is no supplementary feeding. Ewes have to be pinched sometime over the winter, and it is our experience that the best time is early on. If this is done, on most of our hill country we can get good growth in April and May, and fairly good growth in mid-June. You have to do them hard sometime. In most of the hill country where it is well stocked, do it early—it can do little harm early, but a lot later on. As regards the effect on wool production, it may reduce the wool clip by 10 to 13 per cent if the treatment is severe, but it may be considerably less. You get a higher incidence of cotting. I am sure it is impossible to feed the ewes well right throughout the winter on the hill country unless you definitely understock, a situation which I do not like to see on hill country.

Q.: In your opinion, what effect on the economics of the flock, has the practice of pre-lamb shearing?
A.: Pre-lamb shearing is commonly practised in our North Island hills. It has excellent results from the point of view of thrift and of easier lambing. On blackberry country it is also popular. Pre-lambing shearing, and even autumn shearing, is becoming quite a common practice. Most people who have carried it out are under the impression that they can improve their lambing percentages, even to the order of 10 per cent or more. We are carrying out trials but, as yet, we have no data available.

Q.: Do you not leave your rams out for a very short period? Would it not be preferable to leave them out longer with two-tooths?
A.: The practice in the North Island is to leave the rams out for three months—March, April, May. Normally ours are left out for
about eight to ten weeks; we have sometimes extended the tupping season another month thus getting a two per cent increase in lambing percentage, but the late lambs are a serious handicap at weaning. Where development is proceeding, the advantage is not worthwhile for, as only a two per cent increase is obtained, there were very few extra ewes which did lamb. Our results show that two-tooth lambing percentages may be as low as 65 to 70 per cent in the first year, but most of them breed the following year. The number of twice-dry ewes never exceeds 30 per 1000. Therefore, I doubt if it would have much effect on the lambing percentages.
THE ELECTRIC FENCE AND ITS ERECTION

W. R. R. Hewitt, Massey Agricultural College

Papers dealing with all aspects of electric fencing were given at the Sheepfarmers' Meeting in Palmerston North last year in July, and were published in the 1958 Sheepfarming Annual. The whole subject was covered very fully from all angles and is well illustrated with numerous drawings and photographs.

In this paper I intend to describe the erection of an electric fence and to let you know what improvements have been made since then.

Before we started on our electric fence at "Rata", the College property in Hawke's Bay, we made a survey of any existing electric fences that we could find on sheep farms, and the one point which stood out was the very flimsy erection of most of them. A good post-and-wire fence must be strongly erected to last, and I am absolutely satisfied that an electric fence, to be satisfactory, must be erected with the same care and attention to detail. I cannot emphasise this point too much. We set out to design a fence that had to be strong and yet cheap to erect. Our first line cost about £230 per mile. Finally we got our costs down to £167 per mile. Since then we have thought of several improvements and it may be that our costs will go up slightly. For instance, we believe a better fence would be erected by adding another wire and this would put costs up £10 per mile. On the other hand, we have in mind another type of insulator and this, if it is satisfactory, will save £7 per mile.

Today there are on the market many new designs for connecting wires to posts and foots. These, while putting up the cost of materials, have reduced the labour costs, so that it is difficult to say just how much they have increased the overall cost; increased it they certainly have. I will deal with all these new designs as I go along and leave it to you to use your own discretion as to which you use. Costs will be shown against each.

Suffice it to say that the electric fence is here to stay and absolutely satisfactory. It has far exceeded our most optimistic expectation, and I feel that it is only a matter of time before it will displace fencing as we know it on many farms today.

Since the paper was given at Massey last July, I think I would not be over-estimating it to say that well over 100 miles of electric fence have been erected in New Zealand and that this figure is going up every day. Farmers from the North Cape to the Bluff have visited the farm in Hawke's Bay. Many, after inspecting the fence, have introduced innovations of their own and I would stress here that there is room for many improvements. Already one enterprising firm is putting out a "One-third-Mile Pack" with sufficient fittings for one-third of a mile of fencing. This is well packed in a wooden container, 36 in. x 6 in. x 8 in., and two of these make a nice load for a pack horse. Another wind charger is on the market, patents are pending on a new footing process and the whole matter of insulation is being improved. What I may tell you today could be out of date tomorrow.

In designing this fence of ours, costs were of paramount importance. Our ordinary type of fence as erected in the North Island with eight wires, five posts to the chain and 25 battens, was costing us at "Rata" £966 per mile and the Hunter fence £655. For the class of country, this was absolutely uneconomical, and today we have a fence equally as efficient which costs us £167 per mile.
Firstly we recommend that the line should be bulldozed. Smooth out the line and avoid sharp steep dips at all costs. This bulldozing should cost no more than 5/- per chain. In easy country it will cost much less. If you are erecting a line through scrub or fern, I suggest you make it rather wider than the width of the blade. It would have been better if the line in the photograph had been wider.

Once the line is ready all gateways and angles should be sited and erected. We recommend a strongly-built gateway with at least a chain of netting on either side of the gate if it is in the centre of a line. Many farmers have asked if this is necessary. On an intensively farmed property where stock are always being handled and are therefore reasonably quiet, it may not be, but on extensive areas under run conditions it is definitely essential. As one farmer put it to me, “Will a chain of netting be sufficient to handle a mob of 100 breeding cows and their calves?” The answer is, of course, No. You must keep the stock off the live wires and you can well imagine what will happen at a gateway if this is not done.

As you will see, an ordinary post is quite big enough to use as a strainer. It must, however, be properly footed and breasted as the strain exerted on this post is terrific. The method of attaching the wires to the strainer is illustrated in the photograph, and also the method of connecting up the current. The insulators are known as corner insulators and are much superior to a similar type which is made of plastic.

Once the strainers are in place the next job is the erection of the angles and here again an ordinary post is quite sufficient. It is imperative that all the angles are very strongly erected and they should be tied back against the strain. The photograph illustrates quite clearly the method of tying back the angle and attaching the insulators to the angles. This was the first method we used but we have since replaced it with the method used in the second photograph. The materials cost more but there is a considerable saving in time. This second method costs 1/10d for the completed assembly for each wire, and all you have to do is slip it over the angle and one staple will hold it in place. For a five-wire fence it will cost you 9/2 for five assembly units, against about 5/6 for the first way—an extra cost of 3/3 per angle.

Take the time factor with paid labour into consideration and you will find that you would about break even. However, it is just as well to remember that if you are doing the job yourself it is a distinct saving of cash. It could be £3 to £4 per mile if you wish to keep down costs. However, that’s over to you. As I said at the beginning, these new attachments cost money. If you are a hard-up, struggling farmer, do without them until you get on your feet. It is necessary to thread the wires through these angle insulators but this is not difficult and it is quite easy for anyone to pull out long strains through a good many angles.

Once the strainers and angles are all in, a guide wire can be run out and a Waratah standard driven into the ground on all the brows. If the ground is soft, bore the standard at ground level so that it is possible to slip a 7 in. x ¾ in. bolt through this hole. Place two pieces of wood on either side of the standard at ground level and this will stop the standard from sinking.

Now with regard to insulators carrying the wires on the standards. There are several attachments on the market and these are shown in Fig. 6. The two standards on the left are fitted with insulated chain assemblies. We have not tried either of these makes, principally because they are expensive. The one on the left costs 7/10 and the next one to it, 4/9. You simply slip the attachment on to the
standard and tap the bottom plate until the chain is tight. From the electrical point of view I understand that they are more efficient than the ordinary small-bobbin insulator. The 7/10 assembly is beautifully made, will not rust and should last indefinitely. Both have the advantage that your fence wires can be attached anywhere you like by means of a small Hunter Clip which costs about one-third of a penny. Therefore, any gauge that you may require can be easily obtained.

The standard on the right has two types of insulators. The one at the bottom is the one we have used successfully and is known as the small-bobbin insulator which is attached to the standard by means of a 2½ in. galvanised gutter bolt and there is a plastic washer between the base of the insulator and the standard. This is most important as porcelain and iron have different temperatures of expansion and contraction and this washer takes up the slack and prevents breakages. The cost of this insulator is 4d and the bolt, washer, and wire to hold the fence wire in place, 2d more. This means that for an electric fence, with four wires electrified, the cost is 2/-. against either 7/10 or 4/9 using the other methods illustrated—quite a big saving per mile. Admittedly the first two methods are quick and easy and there is a saving in time. The disadvantage of the bobbin insulator is that you can only use the gauge that is on the standard. This gauge is quite satisfactory we consider, although not ideal. Care should be taken in tying the fence wire to the insulator. It must be tight enough to hold the wire in the groove but loose enough to let the wire slide over the insulator should it be necessary to restrain the fence.

The top insulator is one that we have not tried out yet but it is the cheapest of the lot—2½d or 10d per standard for insulators on a five-wire fence. It is made by splitting four inches of half-inch alkathene lengthwise down the centre. Encase the fence wire in this and tie it on to the standard with a piece of soft wire. It has the advantage that any gauge can be used but we know nothing of its lasting qualities. However, it is well worth trying out and we anticipate that it will last a good many years. Remember the bottom wire of the fence is always tied direct on to the standard.

You will notice a piece of alkathene tubing fixed on to the chain on the first standard. It has occurred to us that it might be an advantage to cut the current off the bottom wire if growth should touch this wire at any time, especially in the spring. With this piece of alkathene on all standards and foots, if you were using these assemblies, it would only mean disconnecting the wire from the chain and tying it to the alkathene, and the wire would then become dead provided it was disconnected from the current at the start of the fence.

Once the standards are erected on all the brows it is only necessary to pull the wires down on all dips. When bulldozing the line, avoid as much as possible all sharp dips. Should it be necessary, it is better to put some pipes at the bottom of a small gully and bulldoze a fill over them. Or you can pull the wires down so far on either side of the dip and the space underneath can be blocked with several short lengths of barb wire coming off the foots on either side down to a foot in the very bottom of the gully.

Originally we used the ordinary "Hunter foot" which consisted of a Hunter foot-wire attached to a foot-block which, of course, had to be sunk into the ground. A chain insulated just above the earth wire was attached to all the wires and the fence pulled down by means of this wire and connected to the foot-wire.

The footed dropper assembly which is shown in Fig. 11 appeals to us immensely. It is expensive—10/- for the complete assembly—
ILLUSTRATIONS

1. Fence Line. Eleven standards only were required in the 200 yards to the top angle.

2. Start of the fence showing post used as strainer and method of connecting wires.

3. Recommended gateway construction.

4. Long insulator (1/-) used on the angle.

5. Williams Assembly used on the angle (1/10).

6. (a) Williams Assembly (7/10). (b) Christie Assembly (4/9). (c) At the top 4 in. of split ½ in. alkathene 2½ in. At the bottom, small bobbin insulator (6d).

7. Method of overcoming sharp dips.

8. Hunter foot attached to wire above ground.

9. Hunter foot and insulation chain for attaching to wires (4/3). Hole has to be dry and foot block attached.

10. Five-wire gauge using Williams assembly.

11. Williams Foot Assembly. This foot has only to be driven into the ground and pressure will pull the arrowhead into a horizontal position. (10/-)

12. Hunter method of joining; (6d.)

13. Four-wire gauge on eight-wire standard. Class of insulator shown not recommended.


15. Barrier wind charger unit. (£70/5/-.)

16. Speedrite. (£58.)
but there is a big saving in time. The arrowhead is driven into the ground by placing a round iron bar of suitable length into the hole, which can be seen quite clearly in the photograph, and driving it into the ground to the required depth. Pressure is then exerted on the foot-wire when the arrowhead will pull into a horizontal position and it will require more pressure than the fence will exert to move it any further. The wires are then pulled down with the chain and connected to the foot-wire. This whole assembly which consists of arrowhead, Hunter foot-wire, insulator and clips, and Hunter chain, costs £10/-, and is as cheap as any method we know. If one intended to deaden the bottom live wire at any time, four inches of ½ inch alkathene tubing at the bottom of the chain, just the same as was used on the standard assembly, would be required at an extra cost of 2½d per foot assembly.

All that remains to be done now is to run out the remaining wires and connect them all to the standards and foots. Originally we used an eight-wire waratah standard and four wires, and our gauge was controlled by the spacing on the standard. The bottom wire was an earth wire running the whole length of the fence and it is a very important point. It is connected to every standard and is continuous from one end of the fence to the other. At gateways it must not be broken but should either be taken overhead or under the ground. It is a MUST for an efficient fence.

The next three wires carried the current and were spaced eight, 16 and 27½ inches above ground level. The bottom wire, the earth wire, is four inches above ground level. This gauge fits the eight-wire waratah standard.

It is advisable to strain the fence from the middle and strain it as tightly as possible. We originally used the Hayes strainer as shown in Fig 14 and the connecting wire from either side of the strainer as shown must be used. The cog on the strainer rusts and when this happens you will have trouble. These strainers cost 3/6 each and we are now using the Hunter method of tying the wires. A piece of Hunter chain is tied to one end of the wire and a loop made in the other end. The fence is then strained from the middle and the looped end slipped through one of the links in the chain and a wire pin slipped through the loop. This method cuts your costs back to 6d per wire, against 3/9 using the Hayes strainer.

Our labour costs based on 7/6 per hour were 6/10 per chain for erection. The fence itself is quite efficient and absolutely high enough, a point one may not believe. We have had no trouble with it in any shape or form but we feel that a better fence would be erected by using another wire and using a seven-wire waratah standard. The gauge would then be 4, 4, 4, 4, 12½, an over all height of 30½ in. against 27½ in. on the eight-wire standard.

If you use one of the insulated chain assemblies, you can have any spacing you like and one that is recommended is 5, 5, 7, 8 and 11 inches. However, there is no need for a fence higher than 27½ in. We have used both sheep and cattle to crush country behind this fence and have had no trouble whatever.

We have always used the 12½ gauge Super Dreadnought steel wire and prefer it to 12 gauge galvanised wire for two reasons. It is far stronger and does not stretch.

Lastly, there is the "Barrier" wind charger. The whole unit costs £70/5/- and consists of a windmill £56, controller £10/10/- and battery £3/15/- . The makers claim that this unit will electrify at least five miles of fence and where the insulated chain assemblies are used on all standards will do considerably more. It should be erected in a position where it will catch winds from all quarters. Our experi-
ence is that only once in two years has our battery gone flat, and this might not have happened had we located our windmill in a more exposed position.

Just recently another make called the “Speedrite” has come on the market and this one costs £58. It charges at half the rate of the “Barrier” and as far as we can see requires less wind to operate it. As we have only just commenced a trial with this machine, we can offer no comments. Both these machines appeal to us but wear and tear could be substantial in a district such as ours where wind velocity is often at gale force.

There are two other methods of electrifying the fence.

Firstly, the ordinary electric fence controller which works off a six-volt battery. (See Fig. 2.) If this is used we recommend recharging the battery every two or three weeks and it is therefore necessary to have two batteries, one of which can be taken home and recharged by a small trickle charger.

The other is the Electric Mains controller which plugs into an ordinary electric point; the current must then be carried per medium of an overhead wire to the fence. The earth wire should also be carried to the fence and connected up with the earth-wire on the fence. The disadvantage of this machine is that its maximum pulse rate is 70 and we consider that this rate is far too slow. For breaking in sheep, you require 150 and later can run round the 100 to 120. Otherwise, where you have power this machine appears to be the ideal.

I have no doubt you will want to know about growth underneath the fence contacting the wires carrying the current, and so shorting the fence.

Our experience is this. Under intensive stocking the sheep eat right up to the fence on both sides, especially if you use the bottom wire as an earth, and the grass never gets a chance to get long enough to do any damage. Under less-intensive stocking you get a certain amount of growth under the fence and a good sharp shovel is the best and least expensive way of clearing this. We have spent 2½ hours on our 2½ miles in two years. I referred to being able to deaden the second to bottom wire if necessary by use of a piece of 3-inch alkatene tubing on the foots. If this is done, barring the odd thistle, growth will not touch the other wires in our country. Our experience is that even if grass does overgrow the wire in places, it does not short the fence even when wet.

During the years that our fence has been in use, we have had entire satisfaction. Stock, both sheep and cattle, have stayed where they have been put, even under crushing conditions.

I am satisfied that a well-erected electric fence will do everything that a post-and-wire one will do, and at a fifth of the cost.

Finally, with regard to breaking in the sheep to the fence. Some people have condemned the fence because they have not taken the trouble to do this.

We erected an electric fence using seven wires in one of the big holding yards at shearing time. All shorn sheep used this yard. In fact, for the first year whenever sheep were in the yard this fence was on. We have had absolutely no trouble. In fact, you can turn the fence off now and neither sheep nor cattle will go near it. Cattle have never worried the fence at any time. The pulse rate needs to be 150 to the minute at the start and just use prudent common sense in the beginning in handling the stock and you will have no trouble.
GRASS GRUB AND PORINA ON HILL COUNTRY

(i) Ian Menzies, Banks Peninsula.

It is usual for these papers to be based on a success story: "How I increased production by such things as topdressing, irrigation, curing my foot-rot."

To be honest, I should head this: "How I got into the cactus by over-stocking in the year we had the grass grub and the drought." I am going to tell you some of the pits I fell into this last season hoping that perhaps some of you may profit from my experience.

I am farming 1000 acres in the north-eastern sector of Banks Peninsula, nice, sweet, clean country rising from sea level to 1500 ft. We have an average rainfall of about 33 inches, not very well spread, the driest months being the hot summer ones, from November to February.

To offset this disadvantage the winters are usually comparatively mild and pastures are never really dormant, so we can usually skin through the winter without feeding hay or concentrates.

We have had encouraging results from topdressing on some of our soils, though not as spectacular as in other parts of New Zealand. Now you will agree that money is spent on topdressing to increase, or to stabilise production, and usually leads to an increase in stock carried.

I am telling you all this so that you can see how I was led up the garden path.

I have been carrying out a regular topdressing programme since 1945, at first by horse, then by tractor, and now by air. We have greatly improved the headlands, or points, over a period of years, by over-sowing with subterranean clover, which is ideally suited to that country.

In the spring of 1957 we sowed eight acres to lucerne. I decided we were all set to tickle the till, so I kept my cull ewes and a few extra hoggets.

This brings us to April 1958. That was the last month we had a decent rain and a flush of grass. Prospects for winter looked fairly rosy. Since then, at the time of writing this, eleven months later, we have recorded just over 12 inches of rain—to put it politely, "not nearly enough."

As I said earlier, the property runs from sea level to 1500 ft., the lower end of the farm being composed of loess-type soils, originally under tussock, graduating to volcanic soils developed under heavy bush. These latter soils are fairly porous, have a high natural fertility, and are a happy hunting ground for those harmless looking grubs that are under discussion at this conference today. The D.S.I.R. have typed this particular soil as Stewart Silt Loam. It responds disappointingly to phosphatic manures, and grows a wonderful crop of winged thistle in a favourable season. It is the only part of the farm that we have not topdressed. It normally winters 400 to 500 ewes, carrying them right through from the beginning of the winter to weaning, except for a short break from shearing in August, when they are held to the point of lambing on the warmer country.

In June of this last winter we noticed the grass in this area had a very frosted appearance considering the mildness of the weather. It was grass grub all right, and to an extent that we had never previously experienced. The ewes soon began to look very unhappy and...
we had no option but to take them down to lower levels and feed out
the hay stored for spring feeding the dairy herd. Incidentally, our
sharemilker was horrified by this.

It was our first experience of feeding hay to sheep, and we were
quite pleased with it. The sheep came out of the wool well. How­
ever, we could only put less than half of them back on their own
paddocks to lamb. This meant that the rest had to strap hang on the
front paddock.

We prayed for an early and luxuriant spring which, as you know,
was like "manna"—it never came.

I will not indulge in a long moan about the drought. It has
almost been the last straw on the camel's back this season; though
the surprising thing is, how many extra straws you can carry when
you have to.

It seems that Porina was responsible for most of the damage to
our pastures, and 100 per cent in some areas, though we certainly
have the brown beetle too. In October, when we desperately needed
rain, the Porina moths pelting on the skylights in the evenings could
almost fool you into thinking that the drought had broken. When
spring growth did start, such as it was, there was not much left of the
old sward. Nature did her best to fill the gaps with chickweed, flat
weeds and Scotch thistles. Of course, the consequences of grub dam­
age have been exaggerated by the drought, so the issue is not clear­
cut, as it rarely is in a farming problem.

Now, at the end of the season, we still have a big proportion of
our pasture in dead patches, waiting for sufficient moisture to start
a volunteer growth.

On the points it will fill up with subterranean clover. On the
heavier country it seems that many acres will be dominated by winged
thistle and other weeds such as mustard weed and stork's bill. Another
plant that seems to have revelled in this season's conditions is barley
grass.

What shall I do about it all? The textbooks tell me to apply
D.D.T.-super to fix the grass grub, Dalapon to fix the barley grass,
and hormone to fix the thistles. By that time I think I will have fixed
my bank account too.

However, nature seems to have her own methods of dealing with
plagues of all descriptions. A couple of years ago we had a plague
of mice. They went, where I do not know. The cats could not cope
with them. After a while they would not look a mouse in the face.

It seems now, from careful investigation, that either the grub
has succumbed to the drought, or moved on to a happier hunting­
ground. I believe where there is a regular topdressing programme,
protection against grub should be incorporated. In the case of soils
where it is not economic, I would suggest that a careful inspection
with a spade, in the autumn, would insure against being caught out
by heavy infestation, and that it be combatted by applying a light
application of D.D.T.-super, special strength.

It might be worthwhile adding molybdenum, too. I do not think
this last suggestion can be harmful and it could possibly pay a good
dividend, which is extremely unlikely from one application of straight
super. I am really out of my depth here, but in nearly all of Dr
Walker's trials on the Peninsula the molybdenum plots showed a
response. I can also quote the instance of almost magical rejuvena­
tion of an old stand of lucerne, previously limed and supered, after
being treated with molybdenum at Fisherman's Bay.

To sum up, it appears that grubs come and grubs go, but they
prefer a loose hill pasture of generous autumn growth. When con­
ditions are right, watch out, Porina will have you.
I have been asked to tell you what I know about grass grub and Porina caterpillar in tussock country and given ten minutes in which to do it. I think that is a generous allowance—what I really know would not take me more than a minute and a half to tell you!

However, I have had some experience, I have made a few observations, and I have got some theories. For what they are worth, here they are.

It has occurred to me recently that damage to high country vegetation by Porina and Odontria may be more serious and more common than we have suspected, and I think we ought to take a look at the possible implications of this idea.

My personal observations have been the result of three specific experiences, each of which was striking and significant in its own way. In each case the nature of the damage suggests that the main cause was Porina, and I shall treat them as if this was the case, though it is quite possible that Odontria, which is always present to some extent, contributed its share.

The first was in a recently-sown grass paddock. Establishment of pasture had been good but the sward was predominantly white clover and grasses were weak. In early summer the paddock was so white with clover heads that it looked like snow and several people asked me if I was going in for small seeds. I fed it off rather late in the summer and did not observe anything peculiar about it at the time. The following spring there was not one blade of grass or clover in the whole thing; the Porina had "swiped" the lot, leaving only an occasional plant of mouse-eared chickweed to break the monotony. Chemical ploughing has nothing on Porina, I can tell you. The next time I sowed that one down I used D.D.T.-super.

The second occasion occurred three years ago and gives an interesting line on danger periods. I cut a paddock for hay in early January. Some patches were rather stony and I left one of these uncut to save mower knives. The hay growth on this area was not effectively grazed after the hay was off and in the following spring the ground there was absolutely bare except for a small amount of cocksfoot and the usual weeds. The remainder of the paddock appeared to have taken no harm whatever.

The third experience took place last season on a 1200-acre block of topdressed hill. 1957-58 was a wet season and clover growth was unmanageable (or, at least I failed to manage it) during the summer. Porina moth infested the area and the caterpillars attacked the brown top, which was the predominant grass on the hill, as much as they did the clover. As usual, damage was not very noticeable till the spring, but by September it was clearly serious and I was not able to stock it as I had intended. Moths hatched on this sunny face as early as 1 October, and during October and November it was almost impossible to see out of a lighted window for the moths swarming on the glass.

It now appears to me that in that season quite considerable damage was done to vegetation of various kinds on unimproved as well as on improved country. It was particularly noticeable on poor-quality flats with sparse tussock, browntop, sweet vernal and dianthusia associations. Some of our musterers remarked to me on the patches of dead tussock to be seen. This is still noticeable and I think I am right when I say I have never seen so much dead tussock before.

Now these three instances all have a lesson to teach us, and I think the last one suggests a question worth investigating.

The first example shows that Porina, and possibly Odontria, are present in sufficient numbers in the high country to cause very serious damage to cultivated paddocks if they are allowed to get rank at the
critical time, and illustrates the fact that this damage can be extremely local in its incidence.

Example two suggests that the critical time is later than is usually believed. It appears that caterpillars present in early January may be destroyed later if cover is removed.

The third example has wider significance, and I propose to give it more attention.

The first thing that comes to mind is that by pasture improvement we may be laying ourselves open to increasing the good supply not only of our productive stock but also of a lot of undesirables as well! The epidemic nature of Porina damage resulting from seasonal conditions has led farmers to regard it as a periodic scourge which is not usually very frequent. With a sudden increase in vegetative cover and in palatable food, it would not be surprising if the attacks became more frequent and more intense. Our experience this year suggests that an improved area can withstand an attack of great severity, but what about the surrounding country?

This brings us to the question of what has happened in the past, and I am going to suggest a line of thought which may be worth investigating.

The Porina is a native and must always have been present in the tussock country. Like all natives, it had probably maintained a balance with its environment, and the native vegetation was adapted to withstand its normal incidence. Settlement of the high country brought exotic grasses and clovers, some of which were sown on the hills and some in concentrated areas of cultivation. Either of these methods could result in an increased food supply, and the concentrated areas in particular could cause a sharp increase in Porina population.

As you all know, depletion of ground cover has been the cause of some erosion. Anything which attacks and reduces ground cover has contributed to erosion and also to a reduction in carrying capacity. Should we not consider whether Porina and Odontria have been a factor in this depletion?

I referred before to dead tussocks. It seems unlikely that Porina would attack tussock, but quite possible that the root-feeding Odontria would.

What I have suggested is rather a horrible thought—that, by improving selected areas of tussock country, we may be breeding up a population of insects which will further deplete the unimproved country. But, however horrible the thought, we had better face it and see what weapons we have at hand.

Our first weapon is management of stock to control rank grazing at crucial periods, and these periods should be better known and understood. Our second is D.D.T. or similar insecticide. I feel that the cheapening of this product is one of the essentials of scientific investigation in the agricultural field, for we cannot afford to grow grass for insects to eat.

(iii) J. M. Kelsey, D.S.I.R., Ashburton.

It is intended to confine this talk to a discussion of hill country over which it is impossible to take ground equipment for DDT-super. application. Thus the following remarks refer only to what little work D.S.I.R. has done to control the grass grubs and Porina in hill country, and to tests carried out by the Department of Agriculture and D.S.I.R. on various methods of applying super-, DDT-super-, or other DDT preparations.

Damage by grass grubs and Porina in hill country is normally of the type which slows up pasture growth and reduces quantity of
food available to grazing stock. There have, however, been instances of very severe pasture losses in some districts. Populations of grass grubs are often over three per square foot, not infrequently over 12, and occasionally as high as 70 per square foot. Under individual tussocks in land free of intertussock growth the grub populations may reach 50 in which case such tussocks have roots about two inches long instead of the normal two to three feet. Damage where inter-tussock growth is continuous is much more severe than to tussock itself, and, unfortunately, anything that improves pasture root systems provides better conditions for grass-grub survival; consequently the use of fertilisers on hill country tends to increase grub populations.

Entomology Division officers have not spent sufficient time in hill-country tests to evaluate just how much damage can be blamed on each of the two pests, grass grub and Porina. We do know, however, that the species present in hill country (up to 5,000 ft.) are the same that do most damage on the plains areas.

Tests have established beyond doubt that there is a very definite response to insecticide applications and the only factor to be determined now is how to apply them evenly at the required dosage on hill country which is too steep for ground equipment.

As you are aware, recommendations for control of grass grub and Porina call for application of DDT-super to close-grazed, dry pasture, but hill-country pasture is often long, and on shady faces seldom dries out because of heavy dews present from March to September. It cannot be too strongly emphasised that DDT-super treatments should be applied before damage shows up, as advantage can then be taken of the short, relatively infrequent periods when pasture is close-grazed and dry. There is no really good alternative method. Unfortunately, however, most farmers wait till damage shows up and the only procedure then available is to leave stock off treated areas till at least one inch of continuous rain has fallen to wash the DDT off pasture on to the ground.

The next problem is to apply the insecticide (usually DDT-super) at the correct dosage, evenly over the area to be treated. It is fairly obvious that the only practical method is by aeroplane. Unfortunately, tests indicate that the present types of distributors on aeroplanes are, for the most part, extraordinarily inefficient both as regards swath widths and distribution along lines of flight. Using sticky plates to collect ordinary DDT-super, aerial DDT-super, and DDT-pellets from an aeroplane flying at either 40 or 150 feet in a wind measured at less than two m.p.h., and using a vertical hopper feeding into a horizontally-mounted fishtail-distributor with 18-inch front and 4 feet 6 inches trailing edges, the effective swath width on flat land was only 33 feet at both altitudes. The correct quantity of DDT was applied for the test area, but the distribution from start to end of runs fell off markedly as the load in the hopper decreased, and there was no grass grub control over half the target area, showing, of course, that too much fell while the hopper was full, and too little towards the end of runs when hopper loads were light. Again, the Department of Agriculture, using a wide range of super preparations (some specially formulated for aerial distribution) showed that the loss off the target area ranged from 28 per cent to 100 per cent in winds of approximately seven knots and at altitudes of 200 to 400 feet. It is to be expected that distribution would be poorer at the higher altitudes and wind velocities, but the loss of fertiliser was still 30 per cent to 50 per cent at 70 feet altitudes in winds of eight to 20 m.p.h. Winds of five m.p.h. and over are quite unsuitable for applying DDT-super preparations.

Until there is considerable improvement in equipment for dis-
tributing DDT-super. from aeroplanes, the only solution is to fly over the same lanes twice, the second run being in a reverse direction from the first. An alternative to DDT-super. is the special DDT-pellet type of preparation where a very-fine-particle-size, wettable DDT is bonded on the outside of inert material to form even-sized pellets. It should be borne in mind however that these preparations also are difficult to apply evenly from aeroplanes, and the cost is high for hill country.

Q. Has any scientific work been done on the importance of the relation of bird population to that of the grass grub and porina?

Mr Kelsey: As far as we are concerned, we have done nothing in this connection, but the Animal Ecology Section of the D.S.I.R. are working on it. Starlings are very good at eradicating caterpillars, as are magpies to a certain extent. On irrigated land seagulls feed on cut worms, army worms and caterpillars, but very rarely on the porina.

The porina comes close to the top of the ground in a bubble of air and can exist for eight hours until the bubble breaks.

Q. As even distribution of material on hill country is imperative, could not sprays be used for the eradication of the porina?

A.: Sprays can be used but only under two conditions:
(i) when the land is ploughed (there is very little on hill country).
(ii) Rain should be falling or imminent. (Aviation pilots will not fly in wet conditions.)

The reason for the second stipulation is that we do not want spray sticking on to the leaves of plants as we cannot export any meat whatsoever with D.D.T in it. We must have sufficient rain to wash the spray off the plants into the soil.

Q.: What would be the effect of sowing D.D.T. super in winter time which would be the normal time for topdressing pastures with super by air in hill country? Or, would it not be effective at that time of the year?

A.: There is no definite time for D.D.T. application. If you have a decent pasture, keep it good by using D.D.T. super. If you do not, you will let the grass grub and porina in. But, I would warn you that if the pasture is damp when you apply it, keep your stock off it till the D.D.T. is washed into the soil. It will take half an inch of rain to wash it in. If D.D.T. is topdressed on to damp pasture and it dries on, it takes three inches of continuous rain to wash it off the plant.

Q.: Many of us on the plains have had very disappointing results with D.D.T. particularly over the last year. Is D.D.T. becoming less effective than it was? Last winter, admittedly, we had a lot of long, dry periods. Do you think that is the explanation why we did not have the results, or do we use insufficient D.D.T.? Or, has the grass grub built up a resistance to the D.D.T.?

A.: There has been no evidence whatsoever that the grass grub or porina are building up a resistance to D.D.T. Naturally, you will get poor results by using poor mixes or if it is applied poorly, or, on the other hand, if it is grazed too soon. The position is very acute as the mixes have been often terrible with a variation in the wet mix of 42 per cent between the D.D.T. content in the lowest and highest bags in a batch, and with the dry mix 72 per cent variation. It could be overcome by using the new D.D.T. super whereby the D.D.T. is mixed with the phosphate in the beginning, as opposed to the D.D.T. being added to the super after the super has been made. The fertiliser companies have not greatly improved their mixes since they first started mixing D.D.T. super in 1950.
Where the farmers mix their own D.D.T. with super, provided they make the effort they can make a good job of it. It can be done either with shovels or concrete mixers. When using shovels turn the D.D.T. and super over four or five times as with cement, shingle and water for concrete mixing. This is quite efficient. When using the concrete mixer (25 r.p.m.) you need only let it revolve for approximately three minutes. This also makes an almost perfect mix. If the D.D.T. is of very fine particles, properly mixed, and applied carefully, you cannot help but get good results and get the grass grub and porina under control.

The dry conditions last year were quite general, and would lead to the failure of D.D.T. against the grass grub. To have any effect at all, it must work into the soil. However, this does not apply to porina. Where D.D.T. pastures are cut for hay or seed, it does not give good protection beyond one year. It has been suggested by farmers that with lush growth the D.D.T. is taken up by growing plants from the soil. As it is insoluble in water it can not be taken up into the plant.

Q.: How long will the protection last?
A.: An application of two pounds D.D.T. per acre will last three years against the grass grub and porina, but only two years against the porina on irrigated land. We have had a lot of complaints about D.D.T. on seed and hay crops. In our trials we had only two paddocks which were cut for seed or hay, and they definitely showed only one year's protection. More research on that is needed.

Q.: As far as Brassica crops are concerned, should we apply D.D.T. when the paddock is still in pasture, or wait until we are ready for sowing to obtain maximum protection?
A.: If the D.D.T. is treated while in pasture you may lose a bit. We recommend cultivation for sowing and broadcasting D.D.T., or mix with fine lime and broadcast.

I would warn you against drilling in D.D.T. super with your root crop. Some farmers have got good results, but we have seen crops destroyed with grubs moving in from between the drills.

Q.: Could you apply D.D.T. as a dust through a 20-foot dusting boom?
A.: We have not done any tests on that, but it is being experimented with by some commercial firms. This should work providing the D.D.T. goes on to the pasture and is washed off subsequently. A lot of the mixture may blow away of course. You need only very fine particles on the ground and it does not matter very much how it is put on.

Q.: Earlier Mr McLeod raised the question that local improvement of tussock country may establish nurseries of grass grub and porina which would then lay waste other open tussock country. How far do these grubs travel?
A.: We do not actually know. We did study how far grass grubs travelled but only under laboratory conditions. There they travelled 27 feet. In the field they probably go considerably further than that.

As far as improved pastures are concerned in relation to the grass grub production, the grub prefers the improved conditions to tussock land and populations are built up very sharply.

When you replace tussock with English grasses you have a continuous root system which will house an increasingly large number of grass grubs per acre each year. If you are going to go in for these improved grasses, you have to look out for insect pests.

Q.: How far would the egg-laying female of porina travel?
A.: We do not know for sure, but feel that it is not very far. In tests we have estimated a maximum distance of just under a quarter
of a mile, but normally when the female emerges from the ground she mates and the eggs are usually laid where she emerges.

Q.: The prospects of successfully treating pastures by chemical methods are somewhat uncertain. Can you suggest any other factors such as pasture control which will minimise the effect?

A.: It is true that the close grazing of pastures reduces the population of caterpillars in the early stages. For the first four to six weeks after hatching, the caterpillars feed on top of the ground.

Mr Turton: For the second-class country no man in this century has done more than Mr Kelsey. I want to pay a tribute to a great man for his services to the farming community.
FARM WATER SUPPLY

A. W. Riddolls, Lincoln College.

Extensive land development and closer subdivision of existing farms have in recent years led to great activity in providing new water supplies and the extending and improving of existing systems. This development has been helped by the timely introduction of plastic water pipe, which is so much easier to install than galvanised iron pipe formerly used almost exclusively for farm water supplies. This activity has resulted in increased demand by farmers for information on water supply problems. This paper discusses some of the more common problems met with in planning farm water supplies.

Estimating Water Requirements

The first step in planning any water supply scheme is to estimate the probable demand, making due allowance for possible future expansion in stock numbers. It is very expensive to have to replace or duplicate pipe lines and pumping equipment at a later stage due to faulty estimating.

Demand is usually estimated on a daily requirement basis for stock, domestic and other needs, including a reasonable allowance for such factors as wastage and evaporation from troughs. This is intended to meet the requirements during hot, dry periods in summer, and would of course be more than ample in winter, but it is the dry periods that put the greatest load on pumps, reticulation and storage systems. Different authorities' estimates of daily requirements for sheep range from three-quarters of a gallon to two gallons per day, but there is little doubt that one and a half gallons per day for ewes with lambs to one gallon per day for dry sheep should be ample anywhere in New Zealand, while many Canterbury schemes designed recently on the overall basis of one gallon per day for sheep have been quite satisfactory. For dairy cattle 30 gallons per day to cover drinking water and milking shed use will be ample, except that where modern high volume shed washing pumps are used these splash a lot of water around very rapidly. Dry cattle require about 12 gallons per day. At the homestead such items as automatic washing machines and kitchen garbage grinders are stepping up water requirements and about 50 gallons per head per day should be allowed, with a minimum of 200 gallons per day for the homestead. Additional uses such as garden watering and swimming pools should be allowed for separately.

Community or Individual Schemes

Many farms are served by community water supply schemes, usually in areas where there are no suitable sources of supply on or adjacent to individual farms. Many of the schemes are served by open water races bringing water from distant rivers. I shall not comment on these open-race schemes as a typical open water-race scheme and its problems will be dealt with by Mr D. W. McKenzie in the next paper. In another type of community scheme, water is piped to the farms. The largest piped scheme in New Zealand is the Downlands scheme that serves some 130,000 acres of the rolling country, inland from Timaru, with a good supply of pure water for domestic and farm use, and has had a beneficial effect on production in an area previously unsatisfactorily served by stock water races and farm ponds. The scheme is financed by local body rates. It would probably cost about £700,000 to build today. There are many other piped water schemes throughout the country, ranging from small co-operative schemes serving a few farms up to large community schemes similar to but not as large as the Downlands scheme.
Well-planned community piped water supply schemes have many advantages, including an assured supply of safe pure water for both household and farm use. To encourage development of such schemes the Government in 1956 promulgated a scheme for subsidising such supplies to the extent of £1 for £2, provided that the design is approved by the Ministry of Works, that it serves at least 2000 acres in not less than four holdings, and that the Department of Agriculture reports that it will increase production. So far, in Canterbury at least, farming communities have not taken much advantage of the subsidy, only two schemes having so far been constructed under the subsidy plan, probably because the total capital cost of such schemes appears an enormous hurdle for the farmers who have to find the money, even allowing for the subsidy. Individual schemes can often be provided at a lower initial cost, but when full maintenance, depreciation, operating and capital costs of individual schemes are taken into account, community schemes may well be cheaper.

Developing Supplies from Permanent Streams

Streams often present difficult problems in developing a satisfactory supply. In the first place, the low summer flow or discharge should be measured to ensure that it is sufficient to meet requirements. Discharge of small streams can be measured quite easily by a temporary weir-notch constructed across the stream. In very small streams it may be necessary to construct a dam to provide a reserve supply to allow pumping for short periods at a greater rate than the stream flow. This also allows debris in the water to settle out. Suitable low dams can be easily constructed of planks, logs or wire mesh crates filled with stones. Land-owners with riparian rights can take water from a stream for stock or domestic use, but it may be necessary to get "on side" with the local Catchment Board about the dam.

The intake pipe presents a problem on streams with a moving gravel bed. This can often be solved by sinking a cylinder into the gravel at the side of the stream, made of large-diameter, concrete pipe or even a 44-gallon drum, with the pump intake in the cylinder. This not only keeps the intake clear of gravel but also helps to filter the water.

If the water from a stream is for domestic or milking shed use as well as stock, every precaution must be taken to keep the supply pure. Water can be tested for purity, but the test indicates only the purity of the water at the time of sampling. It could well be polluted by next day. The best assurance of purity of the supply is a catchment survey. It involves an inspection of the catchment of the stream from which the supply is taken, for possible sources of infection that can arise from human habitation, human trespass, and animal contamination from heavy stocking or dead stock. A modern source of additional danger is contamination by the many poisons used as sprays and baits. The local Health Inspector will usually advise on or collaborate in a catchment survey, and can also advise on how to get a sample of the water analysed for purity if desired. But a thorough catchment survey, followed by precautions such as fencing to prevent trespass, is far more important than purity analyses.

Developing Supplies from Underground

Underground water supplies can be tapped either by pipe wells or open wells. Open wells have gone out of fashion in recent years, but they have the advantage of providing large storage capacity that allows pumping for short periods faster than the inflow. But they are very liable to contamination from the ground surface, and should have a watertight lining with a kerb built up above ground level, and a safe cover.

Pipe wells, often called bores, are the most convenient method of tapping underground supplies. The cheapest and most usual method
for farm water supplies is to drive down a two-inch well pipe fitted
with a perforated well point. It is usually better, however, to install
a pipe well of three or four inches diameter, despite the extra cost, as
this allows a larger suction pipe and foot valve and allows a higher
pumping rate. They also allow greater choice of type of deep well
pumping unit, some of which will not fit in two-inch wells.

A geologist or a well-sinker experienced in the area can usually
give useful advice on siting the well. If they indicate, as is usually
the case, that one site is as good as another within a fairly wide area,
the well should be sited most convenient for power supply and reticu-
lation. If you consult a water-deviner you may end up with your well
in the middle of your drive, in the fowl run, under a hedge, or some
other equally convenient site. I would advise anyone who believes
in water divining to read an account of tests of 58 New Zealand
water diviners reported by P. A. Ongley, of the Medical School,
University of Otago, in the Journal of Science & Technology, Vol. 30,
1948-49. He would be convinced that water-divining is about as
reliable a method of finding water as pulling numbers out of a hat. It
is important to get the well-sinker to develop the well by pumping it
out thoroughly so that a good flow is obtained, and so that sand will
not damage the pump when installed.

Wells are liable to contamination, particularly those that do not
penetrate to below an impermeable stratum. A survey of the area
for possible sources of contamination such as septic tanks, piggeries
and manure heaps, should be made before deciding on a site for a
well.

Developing Supplies from Springs and Seepages

If you are fortunate enough to have a free-flowing permanent
spring of good water on your farm you can usually develop a very
cheap, reliable water supply, particularly if it rises on the hills at such
a height that you can pipe water to where you use it without pumping.
But it is surprising how much water can sometimes be got from
small springs and seepages, the only sign of which may be a small
permanently swampy area in a gully, or a small area on a hillside
that seems always to stay green, even in the driest summer, but with
no apparent water flow from the area. Mr J. Brasell, of the Depart-
ment of Agriculture, Palmerston North, reported recently how a
farmer he was advising had obtained a good water supply from a
seepage that caused a swamp at the head of a gully, with no apparent
runoff. A line of field tiles laid around the gully has yielded about
4000 gallons of good water per day, sufficient for most farms. In
another case a small green patch on a hillside, through which only 20
feet of field tiles was laid, yielded about 240 gallons per day, enough
to keep a small trough supplied. In some cases, however, where the
soil is very fine, seepage into the line of field tiles is too slow and the
yield disappointing. If the supply is to be used at the homestead
or milking shed, the seepage area should be protected by fencing and
runoff from higher land diverted, to prevent contamination.

Problems of Farm Pond Construction

We could learn a lesson from Australian farmers in the construc-
tion and use of ponds filled by surface run-off for stock water. They
are often their only source of stock water. If properly constructed
and used, farm ponds, often called dams, give a satisfactory supply,
but most of the ponds constructed here have high losses from seepage
and it is rare to see a dam that has not washed out fairly recently.
It is quite usual here to construct a pond by just getting a bulldozing
contractor in and letting him get to work and build a rough bank in
a gully. Sometimes no attempt is made even to clear the site of
scrub, and as soon as the pond begins to fill the water goes straight
underneath the dam and washes it out.
The following are some of the more important points that are often neglected in planning and constructing farm ponds:

1. The site should be surveyed and the job properly planned and pegged out before work begins. Soil conservation staff of the Department of Agriculture are usually available to assist with this.

2. The pond should have sufficient storage capacity to meet the requirements of the stock, and in addition the estimated evaporation and seepage losses, for a period corresponding to that during which run-off to refill the pond is likely to be negligible. This requires at least six months' storage in most parts of the country, and more in drier areas. Evaporation losses usually account for more than stock usage, and can be as much as three feet in drier areas during the hottest six months of the year. Recent research within C.S.I.R.O. in Australia has resulted in the development of the Mansfield process whereby a thin film of cetyl alcohol is maintained on the pond surface. This reduces evaporation from farm ponds by 25 per cent or more, an important saving. Seepage is often at least equal to evaporation and in badly constructed ponds, or ponds on poor sites, could well be much greater. It is obvious that the deeper the pond the less the proportion of its volume that will be lost by evaporation, so ponds should be at least ten feet deep.

3. The dam that retains water in the pond should be sited so that the ratio of volume of water stored to volume of excavation is as large as possible, consistent with the pond not being too shallow. For example a site in a narrow depression opening out into a wider valley above means that a comparatively small amount of excavation for the dam will give a large ponding area. If suitable sites in a valley are not available, however, a dugout type pond, in which most of the storage is obtained by excavation, may be justified.

4. The subsoil should be preferably relatively impervious, with a high percentage of fine material. The best material for the dam is a gravelly or sandy loam with a reasonable content of clay. The site of the dam should be cleared of vegetation and topsoil and well scarified by discing or grubbing along the direction of the dam to form a key. The soil to build the dam should be excavated from within the reservoir and should be build up in layers six to nine inches deep, each layer being thoroughly consolidated and then scarified before the next is placed. Scrapers or scoops operated by rubber-tyred tractors, working along the dam from the sides, are much better than bulldozers or crawlers, which give very poor consolidation. The soil should be of the right consistency for maximum consolidation, too wet for good tilth yet not so wet that moisture squeezes out as it is compacted. The side slopes of the dam are often made too steep, so that they slump badly, and the base of the dam is often too narrow to prevent seepage losses. With the best compacting soil, bank slopes should not be less than 2½ horizontal to 1 vertical on the water side, and 2 to 1 on the outside. With poorer soils, not less than 3 to 1.

5. The dam should be at least eight feet wide on the top, as it is bound to be used as a roadway. It should be sited, if possible, so that the water face is not exposed to wave action, but if this is not possible it should be protected by a layer of rock or broken stone, or bundles of brushwood well pegged down. The dam should be grassed down as soon as possible to prevent erosion.

6. An adequate emergency spillway must be provided around the dam, sufficient to take the run-off from heavy storms when the dam is full and pass it to a safe outlet below the dam. The bed height of the spillway determines the maximum water level in the pond and the dam should be at least two feet higher than this after settlement. It is best to site the dam where a natural depression forms the spillway, otherwise a wide, shallow spillway should be constructed and well grassed to take run-off without eroding. In areas where rain is frequent, or on sites where there is a permanent stream or spring feed-
ing the dam, it is best to provide in addition a pipe spillway or trickle outlet to take the small flows that would otherwise keep the emergency spillway excessively wet and prevent development of a protective grass cover.

7. The watershed or catchment of the dam is very important. It should be well grassed and should be large enough to provide sufficient water to meet requirements, but if too large, will require a very large spillway to take the runoff; otherwise the dam will be washed out frequently. The actual area of catchment depends on rainfall and soil characteristics of the area. A catchment on the small side is to be preferred, as often extra water can be brought in by means of a graded furrow taken around the slope of the land to lead extra water to the dam. Because of spillway difficulties soil conservators are now recommending farmers to site dams on hill faces instead of in valleys, supplied entirely by graded furrows extending around the face. Although the ratio of storage to excavation on these sites is low, spillway troubles and risk of washouts are almost entirely avoided.

8. Stock should not be allowed access to the pond, but the water should be piped or pumped to troughs. An outlet pipe can be laid in a trench on the dam site before the dam is constructed. It should be fitted with seep collars to prevent water seeping along outside it. It can also serve as a drain pipe to empty the pond for cleaning out. As an alternative to this, the water outlet-pipe can have a floating intake, with a siphon pipe over the dam. This system is being used with success on farms in North Canterbury by the soil conservation staff of the Department of Agriculture.

9. Where soils are naturally too permeable there are various ways of reducing seepage. Carting in clay, then penning sheep on the site and letting them trample it, has sometimes given good results. Bentonite spread and worked in has also greatly reduced seepage. Lining the pond with a plastic sheet has given good results, but is relatively costly.

Water from farm ponds fed by surface runoff is usually not fit for domestic use without treatment to render it safe.

Stored Rainwater

In some areas rainwater from the roof of buildings is the only available source of supply for the homestead. If sufficient roof area is available this can give a satisfactory supply for domestic use but there is always a risk of failure of supply in a prolonged drought. The best way to store rainwater is in large underground concrete tanks with a good roof. Rainwater stored in these tanks will keep cool and sweet. The water can be pumped from the underground tank into the domestic supply system.

Water Treatment

Some water supplies are initially unsuitable for domestic and milking shed use, but can be rendered suitable by various treatments. Water from underground or from some streams may be so hard chemically due to the presence of salts of calcium and/or magnesium as to render it unfit for domestic use and cause it to deposit scale in utensils and hot-water systems. This can usually be cured easily by installing a zeolite water softener. Firms that deal in water-treatment equipment can also usually recommend special installations to remove iron salts that cause unsightly stains on laundry and plumbing fixtures. Other chemical impurities such as sulphur can also be removed by the appropriate equipment.

Water containing sediment can often be clarified sufficiently for domestic use by allowing it to settle in a large tank. Storage in large volume is in itself a means of purification of contaminated supplies, allowing disease organisms to die out and impurities to settle. This
is only likely to be effective for water which has accidentally become contaminated for a short period. If settlement is insufficient, sand-type pressure filters are available that will not only remove sediment but also objectionable odour and taste caused by organic matter. Filtration will also remove some bacteria and eggs of parasites, but cannot be relied on with certainty to remove all harmful organisms. However, filtration will usually render suspect supplies, such as stock water-races, fit for general domestic use, but drinking water may have to be obtained from another source, e.g. rain water.

If filtration does not render a supply sufficiently pure for human consumption, and there is no other source of pure water, then the water must be chemically sterilised. This can be done by chlorination, but it is difficult to chlorinate individual supplies satisfactorily and the advice of the local Health Inspector should certainly be sought on this problem.

Determining Pipe Sizes

I am often asked questions like this: “What size pipe should I use to take a flow of three gallons per minute?” In this form the question is as easy to answer as “How long is a piece of string?” The discharge of a pipe line of a given bore, i.e. the number of gallons per minute that will flow through it, depends first on the length of the line, and second, on the pressure available to overcome friction in the pipe. The friction depends on the length of the pipe, the diameter, the velocity of the water flowing through it, and the nature or roughness of the inner surface of the pipe. The following table shows the results of some tests made at Lincoln College of the friction losses through half-inch and three-quarter-inch polythene pipe. Figures similar to these for a wide range of pipe bores are available from the manufacturers of the different kinds of pipe.

<table>
<thead>
<tr>
<th>Rate of Flow or Discharge in Gallons Per Minute</th>
<th>Bore of Pipe</th>
<th>½ inch</th>
<th>¾ inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>51</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>173</td>
<td>23</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>362</td>
<td>48</td>
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<td>4</td>
<td></td>
<td>590</td>
<td>81</td>
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<td>5</td>
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<td>123</td>
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<td>6</td>
<td></td>
<td>1213</td>
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</tr>
</tbody>
</table>

This table shows clearly how rapidly the frictional resistance increases with increase in flow and decrease in diameter.

If we now have sufficient information we can use this friction table to find an answer to questions like the one above about what size of pipe we need to take three gallons per minute. Suppose the pipe is 2000 ft long, and is to deliver three gallons per minute to an
outlet at an elevation of approximately 100 feet below the water level in the reservoir supplying the pipe. This means that there is 50 feet of pressure head available to overcome friction for each 1000 ft of pipe.

Inspecting the table of head lost in friction, we try first half-inch pipe. This would require 362 feet of pressure head to overcome the friction head loss in delivering three gallons per minute through 1000 ft of pipe and is therefore useless for the job. But threequarter-inch pipe requires only 48 ft of pressure head, and would therefore be satisfactory. (This method is not mathematically exact, but gives a sufficiently accurate solution for practical purposes.)

Incidentally, pump and pressure-tank pressures are usually stated in pounds per square inch, but for solving problems on pipe sizes using friction tables they must be expressed as equivalent pressure-head in feet of water. This is got by multiplying the pressure in pounds per square inch by 2.31.

Pump Capacity
The pump capacity can be calculated from the estimated daily demand. At times the water will be used at a much faster hourly rate than that found by dividing the daily demand by 24 hours. If the water is to be pumped into an elevated storage tank, it is customary to calculate the minimum capacity on the assumption that the pump will work for eight hours per day; i.e. if the estimated daily demand is 2000 gallons per day, the minimum suitable pump capacity would be 250 gallons per hour. For pressure tank systems, five hours per day pumping can be assumed; i.e. a minimum of 400 gallons per hour. Those are minimum figures, and often larger capacity pumps are chosen.

Pumped Gravity versus Pressure Tank Systems
When the water has to be pumped, then to regulate the pressure in the system and to provide reserve storage, the pump will deliver either to an elevated storage tank or to a pressure tank, from which the reticulation system is supplied. Elevated concrete tanks of as much as 5000 gallons capacity are easily built, using precast concrete staves, prestressed with external circular steel ties. They are cheaper than cement tanks, and much easier for the farmer to build than reinforced concrete tanks of conventional construction. If the pump is powered by an electric motor, a float switch in the reservoir will provide convenient automatic control of the pump. If a suitable hill is available, the water can be stored at a height of perhaps 200 or 300 feet above the delivery points, giving ample pressure, and if the storage reservoir is big enough, good reserve storage. Such a pumped gravity system is the ideal system. The high pressure allows small bore pipes to be installed in the reticulation system; but in areas like the Canterbury Plains, suitable hills are at a premium and tank stands to provide such high pressures are out of the question on account of cost, so pressure tanks are used. These consist of a strong welded steel tank with an air cushion that can maintain the water at a pressure equivalent to that from an elevated storage tank 200 or 300 feet high. The pump motor is switched on and off automatically by a pressure switch that allows a differential range of 20 or 30 pounds per square inch between pump cut-out and cut-in, e.g. the pump may cut in at 80 pounds per square inch, and out again at 100 pounds per square inch. Unfortunately pressure-tank systems, as often supplied, have insufficient air volume.

The following table shows in column A figures taken from a manufacturer’s catalogue of draw-off between cut-out and cut-in for a 90-gallon tank for various pressure ranges. Assuming that the same manufacturer’s 350 gallons per hour pump is being used, as is often the case with this tank, the pump running time between cut-in and cut-out to restore this volume to the tank is also shown.
The draw-off and running time shown in column A are based on the tank being full of air at atmospheric pressure when the pump is first switched on. It is obvious that at the higher pressure range, 100 to 120 pounds per square inch, the pump will be cutting in and out nearly every time a sheep has a drink, with dire results to the switch gear. When some of the air has been absorbed in the water, as often happens, the situation becomes worse.

A great improvement can be made by fitting a device called an automatic, air-volume control to the tank. This consists of float-controlled equipment that automatically admits air to the tank through the pump so that the volume of air in the tank at pump cut-out remains approximately at the level of the float. Thus if the air-volume-control float is, say, half-way down the tank, the air cushion above the water at the pump cut-out pressure will never be less than half the tank capacity. Many manufacturers fit these air-volume controls one-third of the way down the tank, but it is usually better to fit them half-way or even further down the tank, as columns B and C in the above table show clearly. The advantage of a 100-130 pounds per square inch range instead of 100-120 can also be seen. It will be noted, however, that in no case does the pump run for as much as three minutes between cut-out and cut-in.

Mr C. J. Crosbie, of the Department of Agriculture, Christchurch, has made a special study of the question of pressure tanks, and dealt with this problem in a paper given at a recent conference of the engineering section of the Department of Agriculture. Basing his calculation on the reasonable assumption that the pump should run at least three minutes between cut-in and cut-out, he drew up the following table for minimum tank sizes and position of the air volume control for different pumping rates. An allowance has been made for a buffer volume of from 20-30 gallons at the pump cut-in pressure to prevent air being forced into the reticulation system.

The table opposite shows that many pressure-tank systems as at present sold have too small tanks, and insufficient air volume. Unfortunately, air-volume controls as at present fitted do not work well at the higher pressure ranges, but an air cushion can be maintained at the desired volume quite easily manually by occasionally pumping air into the tank with an air compressor or tyre pump, and using a water-level indicator made of transparent plastic tubing or using a test cock to give a visual test of air-cushion volume. The sizes of tank shown are minimum sizes, and if made larger they will give still better performance.

Several cases have occurred in New Zealand of pressure tanks exploding, the top going right through the roof of the pump house. They should always be provided with a safety relief-valve, and they should be tested regularly with a hand water-pump, up to pressures
Suggested sizes of pressure tanks and position of automatic air volume control, based on pump-running times between cut-in and cut-out of at least three minutes.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>40-60</td>
<td>10</td>
<td>60</td>
<td>half way down</td>
</tr>
<tr>
<td></td>
<td>60-80</td>
<td>10</td>
<td>70</td>
<td>4/7ths</td>
</tr>
<tr>
<td>G.P.H.</td>
<td>80-100</td>
<td>10</td>
<td>80</td>
<td>5/8ths</td>
</tr>
<tr>
<td></td>
<td>100-130</td>
<td>10</td>
<td>70</td>
<td>4/7ths</td>
</tr>
<tr>
<td>350</td>
<td>40-60</td>
<td>17</td>
<td>90</td>
<td>half way down</td>
</tr>
<tr>
<td></td>
<td>60-80</td>
<td>17</td>
<td>110</td>
<td>6/11ths</td>
</tr>
<tr>
<td>G.P.H.</td>
<td>80-100</td>
<td>17</td>
<td>120</td>
<td>2/3rds</td>
</tr>
<tr>
<td></td>
<td>100-130</td>
<td>17</td>
<td>110</td>
<td>6/11ths</td>
</tr>
<tr>
<td>400</td>
<td>40-60</td>
<td>20</td>
<td>100</td>
<td>6/10ths</td>
</tr>
<tr>
<td></td>
<td>60-80</td>
<td>20</td>
<td>120</td>
<td>2/3rds</td>
</tr>
<tr>
<td>G.P.H.</td>
<td>80-100</td>
<td>20</td>
<td>140</td>
<td>5/7ths</td>
</tr>
<tr>
<td></td>
<td>100-130</td>
<td>20</td>
<td>120</td>
<td>2/3rds</td>
</tr>
</tbody>
</table>

double the maximum operating pressure, as they can deteriorate badly by internal corrosion. This should be done, of course, with no air in the tank so that if a tank does fail during the test there will not be an explosion. A pressure tank system, however, properly designed and maintained, is a great asset, giving a good high-pressure supply and enabling small-bore pipes to be used in the reticulation system.

Pumping Equipment

The double-acting reciprocating pump is now used almost universally for individual farm-water-supply pumping jobs. Although its efficiency of power consumption is not high, particularly in the smaller sizes, it usually has a good suction performance and will give high pressures suitable for pressure-tank operation. Simple, single-stage centrifugal pumps are worthy of consideration where larger quantities are to be pumped, particularly at low delivery-heads, and where suction lifts are low. It is essential, however, to arrange that the pump is always full of water when it starts.

The suction lift of all pumps is limited by atmospheric pressure, which is 34 feet of water at sea level, but in practice it is inadvisable to install even reciprocating pumps which have good suction performance, more than about 22 feet above the water in the well. This is reduced by about one foot for each quarter mile above sea level. Where there is a long suction pipe, this height may have to be much less because of the extra suction required to overcome pipe friction. Thus, for wells more than about 22 feet deep a pump at the surface is useless, and for small supplies of up to, say, 200 gallons per hour from deep wells, up to two-inch bore, the deep-well pumping-jack is used, with the pump cylinder right down in the well below water level, and operated by pump rods from the surface. An alternative system worthy of consideration is the deep-well jet-pump, in which part of the water delivered by the pump at the surface is diverted through a bypass to the bottom of the well, where it is put through a jet device called an ejector, to boost the suction lift in the suction pipe. These systems work very well with a centrifugal pump, particularly in wells of three-inch diameter or more and at depths of down to 80 feet. They are quieter and need less maintenance than pump-rod-operated systems, and need not be installed directly over the well. The new submersible multi-stage centrifugal pumps, in which the whole pump and attached motor are placed down in the well, are finding favour for
larger supplies, but are rather costly. They are used more for larger supplies from wells of four-inch diameter or more, from depths of as much as several hundred feet.

Conclusion

Obtaining a satisfactory water supply requires careful estimating of water requirements with due regard to future expansion, careful calculation of such factors as pipe sizes and pump capacities, careful selection of the types of equipment likely to be most suitable, and skilful installation and operation of the equipment. The local plumber, bulldozer driver or well sinker, although expert at his particular job, is not necessarily the final authority when it comes to planning water supplies. The farmer would be well advised to take advantage of expert advice and assistance that may be available to him from sources such as the Department of Agriculture, Catchment Boards or Health Department. For large schemes, particularly community schemes involving many properties, it would be advisable to have the scheme designed by a qualified engineer.

In recent years many farmers have found that good water supplies have played an essential part in increasing farm production.
WATER SUPPLY FOR STOCK IN THE
ASHBURTON COUNTY


In the study of water supply for stock in the Ashburton County, some background of the history will help explain subsequent developments. Charles Reed is quoted in John Brown’s “Ashburton—Its Pioneers and Its History” as being the first man to demonstrate open water-races and prove them to be successful, although it has been suggested that prior to this, a race existed on Alford Estate. As early as 1878 a deputation waited on the Ashburton County Council (then its second year of existence) urging the promotion of a scheme to supply the Ashburton and Rakaia plains with water. Later that year the Council voted £10,000 for water supply after a poll of ratepayers was taken. In 1880 the first races were begun. These have grown to the 1,200 miles in 1900 and 2,500 miles at present reticulating the county. Probably the greatest single factor in the closer settlement of the Ashburton County was the thorough network of stock water-races begun in the “eighties”.

The increase in stock figures for the county since this period is as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Sheep</th>
</tr>
</thead>
<tbody>
<tr>
<td>1879</td>
<td>508,262</td>
</tr>
<tr>
<td>1900</td>
<td>738,816</td>
</tr>
<tr>
<td>1919</td>
<td>1,021,348</td>
</tr>
<tr>
<td>1958</td>
<td>1,870,000 estimated</td>
</tr>
</tbody>
</table>

The need for the county races can be gained from an extract from an 1894 Journal reporting that 15,000 sheep per week were being handled through the Tinwald and Ashburton Sale Yards.

This brings us to the last decade, when many farms are becoming highly developed through the use of lime, super, D.D.T., irrigation, and numerous other aids to increased production. The limiting factor to further expansion now becomes water supply. The extent of the expansion in the last decade can be gained from the following figures:

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Sheep</th>
<th>Or in the last five years</th>
<th>Total sheep increased</th>
<th>Breeding ewes</th>
<th>Total cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1948</td>
<td>1,066,000</td>
<td>1952-57</td>
<td>38 per cent. to 1,719,609</td>
<td>42 per cent.</td>
<td>22,287 to 29,638, or 33 per cent. of which beef breeding-cows have increased 123 per cent.</td>
</tr>
<tr>
<td>1958</td>
<td>1,870,000 est.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985?</td>
<td>4,500,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It becomes the responsibility of governing bodies, either Governments or County Councils, to assist in water schemes where no other alternatives are available. In the Ashburton County and similar plains areas of the South Island, what alternatives are available?

1. The open race system,
2. Pipe reticulation (such as the Downlands Scheme).

Dealing with (2) Pipe reticulation first. In 1953, Mr Lindsay, Engineer to the Ashburton County Council, prepared estimates of a pipe reticulation to replace the so-called obsolete open-race system. The area to be covered was 870,000 acres costing approximately £54
million, or £6 per acre. The cost compared favourably with other projected or existing schemes of that time, viz., Downlands £3 per acre in 1938, or £5 per acre in North Canterbury in 1949. The annual charges against such a scheme were: maintenance £52,000 (one per cent of capital cost) and depreciation £130,000 (two per cent) plus loan repayment £300,000 or on a per-acre basis of 11/4. To compare annual costs of the pipe reticulation and the open race, a farm of 1,724 acres would pay £900 on a pipe scheme, and with 327 chains of open race at an annual rate of 2/3 per chain, £37. In another case of 985 acres, it would be £500 or £30 with open races. It is obvious that, where an open-race system is feasible there is no place for piping.

To quote an example and costs of a pipe system where there is no alternative scheme available, the Montalto scheme in the northwest corner of the country is suitable because the costing is recent. The area is above the gravity intake at Klondyke and therefore water has to be lifted approximately 200 feet from the Rangitata River to flow by gravity to the 25 domestic consumers and 12,000 acres of farm land. The scheme was originally designed for stock water only, but has since been extended to some domestic uses, although the Health Department has not officially blessed the scheme for general domestic use. Eighty thousand gallons will be lifted in 12 hours of pumping per day, giving sufficient water for six gallons per acre, and 400 gallons for domestic use per day. Allowance has been made for one trough per two paddocks plus a margin for expansion. This scheme, to cost £55,000, carries a £1 for £2 Government subsidy and the Council will find one-third of the local cost, leaving £24,000 to be raised by short-term loan by consumers. This has been covered by a security rate of 6.5 pence per pound of capital value. Based on loan repayment in five years, a rate of 10/5 pence per acre will be levied.

Now, let us look at (1) The open-race system, to see where expansion is necessary to cope with the demand for subdivision.

(a) Water-race enlargement and reticulation to serve more farms and paddocks in subdivision schemes. The Council is prepared to make extensions to any part of the race system or, even to bring a new race from an intake, to a poorly served area.

The pattern of development of farm subdivision and stock increases has been sufficiently well illustrated on many farms for the Council to prepare estimates of water-race requirements for many years to come. The land development at Valetta is an example of the greatly increased demand in a relatively short period.

(b) Race extension by loops within farms. This has been allowed by the Council in the past, to the extent that flows are reduced, and silting and cleaning become more urgent problems during seasons of growth.

(c) Piped gravity schemes for races. The only drawback, silting of the pipes, can be overcome cheaply by some method of filtration or settling tank. This appears to be a scheme that should be encouraged by the authorities, as being economical in the use of water. At the present time the Council levies an annual charge of £2 per trough in such schemes. Considering the economy of water the charge should be very low or nothing, to encourage this form of extension.

(d) Pumping from races. Where gravity schemes are impractical, pumping by either electricity, petrol or windmill, is sometimes an alternative worth considering. More expense is involved in both power units, and storage capacity is necessary in the event of power failure or during cleaning operations.

Winchmore Research Station has made extensive use of this.
method to water stock on a great number of small paddocks. There are three strategically-placed, underground storage tanks, of 5,000 gallons capacity, filled by gravity from a county race, and then pumped by a pressure pump to supply up to 300 acres. Sifting of the pipe line is overcome by a silt trap built in the line from race to reservoir; then the reservoir itself acts as a settling tank.

(c) Pipe extension of race system by County Council to make better use of diminishing supply of water. Costs would be on a similar scale to the Montalto scheme.

Wells

Where wells are practical, they are a satisfactory water supply for both domestic and stock water. At the 1956 Farmers' Conference Mr B. W. Collins, of the New Zealand Geological Survey, presented a detailed paper on the physical properties of wells.

Although the Ashburton County appears to be suitable for underground water supplies, there are areas where great depths have to be penetrated, while others have such low permeability that storage tanks are necessary. An area north of the Ashburton River from Dromore to Lyndhurst comes into the latter category. A well at the Winchmore Research Station had to be driven to 218 feet to reach water, and was then sufficient only for domestic and laboratory use. I understand there are other wells in the area at about the 200 foot mark.

To illustrate the practical application of some of these alternatives I will give a brief description of our own farm.

The farm situated four miles north of Ealing, 20 miles south of Ashburton, is 1600 acres in two blocks one mile apart. The soil is Lismore stony silt loam, with an average rainfall of 26 inches, although this year only 23 inches fell for the 12 months, with 11 inches from June to January. Temperatures can reach 90 degrees during the summer with the record of 101.2 in 1956.

The history of development of the farm has been much along the lines of thousands of acres of plains land in Canterbury. Lime, super, improved strains of pasture plants, and more recently D.D.T. and flood irrigation, all these measures together with subdivision have increased carrying capacity. To illustrate this trend in subdivision, the homestead block, which has been farmed by my father for many years, originally consisted of 17 paddocks of an average area of 50 acres. Today there are 35 paddocks of 25 acres with 5,000 sheep and 163 head of cattle to water.

The watering of the increased number of paddocks has been by realignment of races with no increase in length, and also a well and pipe system. The well was dug to a depth of 57 feet originally, so presumably this depth was necessary at some previous dry spell. Incidentally, this well was one of the early watering points on the plains coach route. In recent years a pipe was driven through the bottom to a total depth of 67 feet, a four-inch deep-well pump was installed, capable of delivering 900 gallons per hour to supply two houses, a cow shed, and three troughs serving six paddocks. The pump operates between 25 and 45 lb pressure, into 30 chains of half-inch plastic pipe. The plastic pipe was laid into a 12-inch ditch cut by a grader, then backed filled. This proved very cheap and quick in open country, but the risk of pinching the pipe with loose stones is fairly high. This half-inch system, although satisfactory, is working at the limit of its capacity during hot weather, particularly with cattle. If this portion were being laid today, we would certainly lay three-quarter-inch pipe with a pipe layer. Recent extensions to a cottage and cowshed have been with three-quarter-inch and one-inch pipe. Further subdivision can proceed in the knowledge that suffici-
ent capacity and pressure is available to make any extension to our pipe system.

Our second block, purchased by my brother Alan and myself in 1954 consisted of eight paddocks when purchased, ranging up to one of 150 acres, with water in one corner. This block was poorly served by county races in that two races only crossed the narrow width. Before any plans for reduction in paddock acreage could begin, a thorough investigation of possibilities for water supply was made. The only open-race extension was for another race across the property, serving the other end of already-watered paddocks. The Council was approached to join two races, but this was difficult on account of contours; also it is the Council’s policy not to join two races unless they rejoin within a short distance.

A second alternative, a gravity system from the top race, using a windmill to lift to a 10,000 gallon storage tank, was costed at £529 to serve six troughs and 350 acres. The costs were as follows: 25 chains one-inch pipe £116; 25 chains three-quarter-inch £93; storage tank £200; filter £50; windmill £25; six troughs £30; fittings £15.

A third alternative: As at a later date a house to be built on the property would be located at the road frontage and power supply at the other end of the farm, a water scheme to serve domestic and stock purposes was investigated and installed. A well and pressure system to serve a house and 300 acres from four troughs, was costed at £635, made up of: 30 chains one-inch plastic £140; 36 chains three-quarter-inch £133; four troughs £20; pump and motor £150; well 71 feet at £3 per foot £210. Although it was fairly stony country the 66 chains of plastic pipe were run in 18 inches deep with a pipe layer. A run without the pipe was made to shift any stone that might prevent laying the pipe the full 18 inches. With the pipe down the full depth, any cultivation or even border-dyking can proceed with confidence. Altogether 80 chains were laid in six hours. Although the water level has not dropped below 40 feet, the well was driven to 71 feet to be on the safe side. A three-inch deep well pump and pressure tank and an electric motor of one horsepower supply the system.

That the scheme has sufficient capacity was proved during a week this season when the temperatures were in the 90’s with 1600 ewes and 26 cows on one trough. At no stage were the stock without water.

We have noticed that dry sheep drift off for water at any time of the day, while cattle and ewes with lambs prefer to drink at the one time. Another observation, that ewes and lambs graze nearest the trough, could be overcome by locating the troughs in the centre line of paddocks. It appears certain that stock have no preference for well or race water, as when stock are being shifted from a trough-watered paddock to a race-watered paddock or vice versa they will nearly always run to the watering point.

To summarise, the county race system has catered for a doubling of the stock numbers, but can it water the increased number that will certainly be carried in the next 25 years? If not, the following alternatives have been suggested:

(a) Extension of the present open-race system;  
(b) Piping from the present system by the farmer either by gravity or by pumping;  
(c) Piping extension by the County Council to utilise small flows at the bottom of the race system;  
(d) Underground water.

Finally, always use pump and pipe of sufficiently large capacity to allow for future expansion.
STOCK HEALTH, PROGRESS REPORTS ON
WHITE-MUSCLE DISEASE AND
ILL THRIFT

(i) Lindsay Morris, Mt. Barker, Wanaka.

Most of the papers given at these conferences have been given by successful farmers. In this paper I have to relate a story which is not one of success.

We have all heard a lot about white muscle and ill thrift during the last few years. To those of you who have only heard about it I wish to say that you are very fortunate. For those—and there are a good many—who have experienced the trouble in their flocks, there is now perhaps a ray of hope for the future.

As I have just said, we have heard a lot about this trouble during the last few years, but it is not new; I am sure I have had it for the last 16 years.

My farm consists of an area of 640 acres of light terminal-moraine land, just two miles east of Wanaka, with an average rainfall of 22 inches. In 1938, with a partner, I took over from my father. Like most of the farms in that area it was cropped out and we set ourselves to the task of building it up again. In 1940 we put in an irrigation race to cover 180 acres. This produced, in a few years, lush clover-dominant pastures which looked very pleasing to the eye but, at times, failed to produce the expected robust fat-lambs.

This paper deals with white muscle and ill thrift but with that I should like to include infertility. In the Wanaka area, and in certain other areas, the troubles go hand-in-hand.

As infertility in the ewes has been our greatest trouble, I should like to deal with that now.

Here are the actual lambing figures:

<table>
<thead>
<tr>
<th>Year</th>
<th>Ewes put to Rams</th>
<th>Lambs Tailed</th>
<th>%</th>
<th>Ewes bought in</th>
</tr>
</thead>
<tbody>
<tr>
<td>1940</td>
<td>305</td>
<td>312</td>
<td>102</td>
<td></td>
</tr>
<tr>
<td>1941</td>
<td>350</td>
<td>353</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>1942</td>
<td>350</td>
<td>359</td>
<td>102</td>
<td></td>
</tr>
<tr>
<td>1943</td>
<td>358</td>
<td>375</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>1944</td>
<td>445</td>
<td>413</td>
<td>93</td>
<td></td>
</tr>
<tr>
<td>1945</td>
<td>350</td>
<td>220</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>1946</td>
<td>250</td>
<td>162</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>1947</td>
<td>200</td>
<td>261</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>1948</td>
<td>186</td>
<td>235</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>1949</td>
<td>292</td>
<td>266</td>
<td>91</td>
<td></td>
</tr>
<tr>
<td>1950</td>
<td>577</td>
<td>554</td>
<td>94</td>
<td>300 Distance</td>
</tr>
<tr>
<td>1951</td>
<td>690</td>
<td>454</td>
<td>66</td>
<td>600 Distance</td>
</tr>
<tr>
<td>1952</td>
<td>830</td>
<td>774</td>
<td>93</td>
<td>450 100 Neighbour</td>
</tr>
<tr>
<td>1953</td>
<td>800</td>
<td>564</td>
<td>70</td>
<td>350 Distance</td>
</tr>
<tr>
<td>1954</td>
<td>800</td>
<td>710</td>
<td>89</td>
<td>200 Neighbour</td>
</tr>
<tr>
<td>1955</td>
<td>900</td>
<td>780</td>
<td>86</td>
<td>150 Neighbour</td>
</tr>
<tr>
<td>1956</td>
<td>1000</td>
<td>810</td>
<td>81</td>
<td>100 Neighbour</td>
</tr>
<tr>
<td>1957</td>
<td>1000</td>
<td>284</td>
<td>29</td>
<td>250 Distance</td>
</tr>
<tr>
<td>1958</td>
<td>1050</td>
<td>527</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

= 79.5% 1940-1958
For the last 16 years I have been combing the brains of all the veterinarians, scientists and farmers I could find to discuss the problem. We have tried to tie the low lambing percentages to all sorts of causes. Firstly pizzle rot in the rams, then over-fat ewes, then subterranean clover, then flushing the ewes on lush pastures of white and red clover. Finally, we thought about having developed a flock of low fertility.

Here I should like to pay a tribute to the Department of Agriculture; they have been most co-operative all these years. Unfortunately, they could not find another farmer in the whole of New Zealand with the same consistent low lambing-percentages. And our own neighbours had good lambings. It, therefore, appeared to be inescapable that the fault lay in my own management, though where the fault lay did not appear.

For a good many years now I have thought the trouble was due to a trace-element deficiency, and have read up all the articles I could, and talked to every available veterinarian, doctor, professor and scientist. Always the answer was the same. There is no known trace element which causes infertility.

Six months ago Dr A. B. Grant, Principal Scientific Officer at Wallaceville, appeared on my door-step with a bottle of selenium shining through the gloom.

As an experiment in 1955 I had used tupping paste on the rams to find out how many barren ewes to expect at lambing. The rams were not pasted until after the ewes' first cycle. In the second cycle, out of 900 ewes 128 were marked; then only 33 came back to the ram on the third cycle. Naturally I looked forward to a good lambing with only a handful of barren ewes, but instead of the handful there were 180. The question then was, "Had those dry ewes not taken the ram at all?" So the next year the rams were raddled from the beginning. The pattern was the same; all the ewes took the rams, and only a few were returning on the fourth cycle. Again the lambing could not be related to the tupping. I haven't all the figures for that year, but an early-lambing mob of 80 ewes produced 36 lambs, mainly due to barren ewes.

That was just one of the many experiments tried which did not lead anywhere.

When I gave Dr Grant these facts and figures, he immediately pointed out what I hope is the answer.

In the laboratory, if female rats are fed on a vitamin E deficient diet they reabsorb the foetuses. Now, if the same thing applies to ewes, we know why they did not produce lambs when the tupping paste trial said they were in lamb.

For many years now we have known that Vitamin E is tied up with fertility. Also we know that these clover-dominant pastures are stacked full of Vitamin E. What we did not know, but hope to prove, is that without the trace element selenium present, the Vitamin E in the pasture is not available to the stock.

This year we are dosing the ewes each month with selenium, and have an untreated control group of 100.

Later on in the day, research workers are giving papers and I hope they will explain more about the work done in this field.

I have not kept accurate figures of lamb deaths through the years, but would give a rough estimate of about 20 per cent from tailing until say mid-winter.

I have always managed to fatten all the survivors, some years with great difficulty, except for the usual few "tail-enders" kept for farm mutton.

The year before last we had a 29 per cent lambing. This was brought about by 40 per cent barren ewes and 40 per cent of lambs
either dead at birth or within a couple of days. The deaths were then attributed, we think, wrongly, to goitre.

Last year the ewes were filled up with iodine, but again, we had 40 per cent of barren ewes and 40 per cent of deaths from ewes native to the farm. The lambing would have been again 29 per cent or less, but for 250 annual draft ewes bought in, where only 36 were barren, and the lambs from the other 214 were almost free of white muscle. In this case about half our lambs came from a quarter of the flock which had been bought in from a distance.

Similar, but less-severe results can be seen in other years from the lambing chart.

The two very wet years 1957-58 virtually transformed all our neighbours into irrigation farms, so that the incidence of empty ewes, with a correspondingly high incidence of white-muscle disease, spread to them. This is borne out by Dr Grant's statement that where the empty ewe incidence is over 30 per cent, white-muscle disease is more often congenital.

When the last lambing had been going for a few days it was apparent that trouble was ahead, so the Department of Agriculture Veterinarian, Mr I. M. Cairney, was called and diagnosed white muscle on his first post-mortem. We drafted off the barren ewes and dosed the remainder with Vitamin E. A few days later Dr Grant appeared with more Vitamin E and the bottle of selenium.

We then had the ewes split up into small mobs on set stocking to save driving. Each week we set up yards in each paddock, docked the lambs and dosed them—half with Vitamin E and the rest with selenium. They had nine weekly and three bi-weekly doses.

There have been no deaths in the group of lambs which were dosed with selenium. Ten deaths in the Vitamin E group, which all showed white muscle on post-mortem, would have been previously called ill thrift.

There were 262 lambs in each group.

On 18 December the lambs were drafted for the works. Here are the figures:

<table>
<thead>
<tr>
<th>Lambs</th>
<th>Av. Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selenium group</td>
<td>107</td>
</tr>
<tr>
<td>Vitamin E group</td>
<td>53</td>
</tr>
</tbody>
</table>

During the past summer the drought from early January prevented the growth of any lush pasture except in one case. Here the farmer having permanent irrigation water, could maintain lush pastures. In part of his flock lambs developed what appeared to be ill thrift. This proved at post-mortem to be due to white muscle disease. At once the lambs responded to selenium and the deaths ceased.

The facts and figures quoted will justify, I think, the ray of hope promised at the beginning of this paper.

(ii) C. B. Hercus, Hakataramea Station, Kurow.

In presenting this paper I will endeavour to give some results of work done at Hakataramea during the past season. I would, however, stress that the results gained have only one season's experience to support them, and any conclusions drawn must be judged accordingly.

White-muscle disease has been known on the station for very many years and losses at shearing time have been severe in many seasons. I recall 73 lambs going down with this disease out of one mob of 450 ewes while the ewes were being shorn. This was in 1953, and similar losses have occurred before my time on the station. In my time, some cases have occurred every season. This significant factor has become obvious in checking over station records; stock
losses have been heavy following lush growing years when hay has been saved and fed during the winter. I have reached this conclusion, that when stock do not do well on pastures, it is unwise to save hay from these paddocks. If you do, white-muscle disease invariably becomes heavy in the following lamb crop.

In normal dry years, this disease does not prove serious. Also we have not had this trouble after Christmas until this past spring, when some hoggets had this disease. We also found mutton wethers, this past season, showing signs of this disease after slaughtering.

Trials were conducted by the Department of Agriculture this season by injecting ewes with selenium and vitamin E, prior to lambing, for the control of white-muscle. Possibly this work was commenced too late, but selenium gave some measure of control, but the vitamin E group had a heavier death rate in the lambs than the control group. The overall loss of lambs from white-muscle in this trial was nearly 25 per cent of lambs born. By giving lambs badly affected with white muscle disease, some nearly dead, two or three drops of selenium, they invariably recovered. Vitamin E proved of little use as a control.

III-Thrift

Serious as white-muscle disease is, I doubt very much if it accounted for 25 per cent of our lamb and hogget losses. So called ill-thrift followed closely on the white-muscle outbreak in 1957-58 season. Possibly those present today have read or heard of my observations appertaining to this trouble last winter. Nothing we tried that year proved of any benefit. This included drenching with phenothiazine; copper, cobalt, and iron; cobalt bullets; copper alone, and cobalt double-strength. In post-mortems no moderate-to-high worm infestation was found at any time. No one could say why the lambs died. All samples sent to Wallaceville were reported non-pathogenic. The only opinion given by veterinarians was that it was not worms and it was not pulpy kidney. From November onwards, lambs did poorly and good lambs wasted away, many dying. At this stage the only post-mortem symptom common was a heavy inflammation of the fourth stomach such as is usual with heavy infestation of Ostertagia worms. After weaning, some mobs of lambs did moderately well and others no good at all. This strengthened my belief that some areas suffered a mineral deficiency. Lambs on rape did very well. The stud lambs on paddocks topdressed with copper, cobalt, and iron did well. In late autumn we put the drenching trial lot where all groups had lost an average body weight loss of 4 lb per week on to one of these paddocks treated with copper, cobalt, and iron, shifting them by truck, because of their low condition. They continued to do poorly and many died. Some lambs, having done quite well for some time, started to pack up. We put these with the others on the rape. The whole mob then gave trouble. The stud ram lambs were moved in late autumn to a paddock which had been spelled for three weeks, but where lambs had not done well previously. The first week they did well, but then rapidly packed up. These were then put on swedes, giving them hay, chaff and nuts. The stud ewe lambs we fed on the opposite end of the swedes. The ewe lambs settled down well, but the ram lambs roamed their break. We changed the two mobs over. They still showed no improvement. The only result of this was the ewe lambs then packed up. Both lots continued to die all winter.

The story with the flock hoggets was very much the same pattern. After a shift, losses would stop, then one or two would die. As soon as this happened, losses of 50 or more a day would occur within the next few days. A shift, and losses would drop sharply, and then rapidly build up again. Thrifty lambs and unthrifty lambs all succumbed within a few hours of appearing sick.
The post-mortem symptoms in the winter deaths were still showing the inflammation in the fourth stomach, but sections in the intestines now showed signs of acute inflammation. Deaths occurred in a few hours of hoggets first showing any sign of being sick, odd ones within an hour. We spent all winter trying this and that, sending samples away, changing feed, etc., but nothing we did seemed to effect any improvement. Towards the end of the winter it struck me that the hoggets were being affected from the scour of the sick hoggets. The stud hoggets were then moved to a fresh paddock each day. The results were spectacular. Instead of an average of five hoggets dying per day, during the next ten days only two deaths occurred, and these were the last losses we had. This was easy enough to do with small mobs, but when handling hoggets in thousands under winter conditions, this procedure is almost impracticable.

There is little doubt in my mind that the losses were bacteriological. From sick hoggets, but before natural death, the Otago Medical School confirmed this, but samples taken from dead specimens proved most difficult to obtain results from. Unfortunately research workers at Wallaceville have been unable to definitely type the bacteria responsible.

Dry Ewes
The number of dry ewes in the flock this last season was alarming. In the two-tooth ewes, all but a little over five per cent were barren. As hoggets these clipped an average of 10 lb of wool at shearing. I mention this fact so that you can visualise the condition of these sheep. The older ewes on the paddocks were a little better and ewes tupped on tussock and away from areas where hoggets had been grazed, lambed normally. White-muscle disease showed up in the lambs where the percentage of dry ewes was high.

As a trial we bought in 100 Romney two-tooth ewes in lamb. These we took delivery of on 21 August. The lambing was satisfactory, with no deaths or trouble of any kind. At the end of September, white-muscle disease commenced in these lambs. With the use of selenium, we saved the ones we were able to give it to. This was followed by the bacteriological infection, but by moving the mob around, this was soon under control. The same conditions occurred with our own ewes, but with the light lambing and scope for moving together with a dry spell, this was soon brought under control. Under dry conditions the infection does not appear to last on the ground beyond a day or two. Under damp, moist, growing conditions, I believe it lasts a very long time. From observations made at Hakataramea, I think it probable that so-called ill-thrift is a chronic type of bacterial infection, which can eventually develop into an acute form.

This could then be the reason why a dense sward of a clover-dominant pasture, with its attendant damp, humid undergrowth generally, has proved the most dangerous.

It would also explain why stock one side of a wire fence are healthy and ones on the other side unthrifty under similar pastures. I have had this experience.

Minerals
Like others affected with these stock diseases, I have asked myself the reason for them. I still believe the underlying cause of all these diseases mentioned is some deficiency. With this conviction, we undertook an extensive programme of trace-element topdressing. This was spread in such a way as to have trials of each treatment dovetailed throughout our area. Copper, cobalt, and iron treatment looked a likely solution on a trial last season, but I feel now it was the movement of the stock before going back on the treated paddocks that was the greater benefit. Topdressing undertaken included the following treatments: fortified super; sulphur plus lime for spread-
ing; sulphur plus 10 lb copper plus lime; fortified super plus copper; sulphur plus iron plus lime; super, copper, cobalt, and iron; copper, cobalt, and iron, plus lime.

Out of these trials the only treatments which gave any worthwhile benefit as far as I can judge have been the spreading of sulphur, either alone or in mixtures. I have noticed stock will graze sulphur-treated areas and leave untreated ground alone in some cases. Sulphur, however, takes some time to work under dry conditions. This bears out the small work done with sulphur here last year. Prior to the application of sulphur on our lucerne, we could not safely graze it, and lambs would not thrive. This year they have done well on the same area. On another area adult sheep would only exist or lose condition. For the first time in six years stock have done well on it. A bare minimum of 20 lb of sulphur seems necessary with super, 30 to 40 lb if applied on its own. What the long term effect of continued use of sulphur would be, I do not know. With the amazing results which a minute quantity of selenium have shown on lambs affected with white-muscle disease, it is highly possible that the small amount of selenium present as an impurity in sulphur may be responsible for these results.

Conclusion

Last season those of us suffering from these stock diseases were baffled, and different ideas and theories were advanced. Unfortunately, farmers are loath to advertise their troubles fearing a hurt to their professional pride. I share this view. To hear over the air that it is all a question of management from some speakers, does not help. This may well be, but I have yet to hear of a system of management which will overcome these sheep diseases. The result of all this has been that the seriousness of this problem has not been appreciated by those best qualified to help. An eleven-months lag occurred before any practical help came my way. I believe it was only the publicity given by individuals and farmers’ organisations which stimulated the official mind. However, I do now believe that Wallaceville is really on the job with keen and capable men, slowly unravelling the reason for these problems. There is light on the horizon.

(iii) A. N. Bruere, Waikari.

My position, in this panel of men gathered here to discuss the problems of white muscle disease and ill-thrift, is merely that of a general practitioner. I have no advanced or specialised knowledge of this subject in particular, and any information I am giving you is largely what I have seen and experienced in a period of five years while in practice as a veterinary surgeon in North Canterbury. A lot of the ideas and impressions I intend discussing are not necessarily derived from controlled experiments or the methods of research workers, but it is encouraging to know that at least some of our impressions have been proved fact by research workers.

I refer to ill-thrift as it occurs in a district bounded by the Cheviot, Amuri and Waipara counties; and I have knowledge of the north part of the Kowai County. In this area there are approximately 900 farm holdings and 750,000 breeding ewes.

Ill-thrift in sheep to my mind is any disease condition or process which causes poor growth or development and wasting and death and, I imagine, can cover a host of diseases including poor feeding and starvation, ill-thrift under drought conditions, or irrigated pastures, parasitic ill-thrift, and ill-thrift due to various dietary or feed deficiencies including such trace elements as copper, cobalt, iron and selenium. We may even have ill-thrift as a result of poor conformation such as the classical case of the wool-blind sheep.
In North Canterbury there are three types of sheep farming. We have the fat-lamb farmers, the store-sheep farmers, and a few back-country stations relying mainly on wool from fine halfbreds and Merino ewes and wethers.

The interesting feature is that we have encountered ill-thrift problems not only on highly-cultivated fat-lamb farms but also on hill properties, and even at least one case on one of the back-country stations running sheep purely on untopped dressed native pasture. The particular ill-thrift in this case was discovered as a result of investigation into poor lambing percentages on this property.

First, I would like to review the position of white-muscle disease in North Canterbury and then mention briefly the other defined causes of ill-thrift, dealing in particular with copper-molybdenum imbalance.

As far as North Canterbury is concerned, white-muscle disease is a type of juvenile ill-thrift mainly occurring in milk lambs either at birth or more commonly at the four to six weeks stage just when they are starting to consume their share of grass. I have seen the disease in hoggets on subterranean clover, and heard of it on root crops, but not as extensive and not as severe as in other districts.

The first large outbreaks of white-muscle disease in lambs I have record of were reported on two properties by the late Mr J. L. Jebson, veterinary surgeon. This was in 1953. At this stage I feel we looked upon white-muscle disease rather differently from what we do now. I, at least, then considered it a specific disease condition which occurred very suddenly. Now, in light of later experience, I feel it is merely the terminal stage of an ill-thrift which probably started some time before. The actual clinical cases in a flock are probably the extremes of a disease from which the greater part of a given flock may be suffering.

Between 1956 and 1957, we did not encounter severe outbreaks of white-muscle disease on the North Canterbury area, but in the spring of 1958 there seemed to be an unprecedented increase in the disease and it was observed on 17 properties in outbreak conditions. There were odd cases on several other farms. Most outbreaks were on farms with light land with highly improved pastures growing predominantly lucerne and subterranean clover. (Do not quote me as saying that this is the cause of white-muscle disease.)

There are two contributions I wish to add to this discussion on white-muscle disease as far as North Canterbury is concerned. As yet, and I repeat, as yet, I do not feel it is a major stock problem to the district but more a particular problem to certain farms. Other diseases, such as pulpy kidney and parasitic diseases, still take a much higher toll of stock. It may never become a serious problem to the whole district if we are fortunate enough in the next year or two in finding a complete means of controlling it.

First, it is important for farmers to know when they are dealing with a white-muscle disease problem—that is to differentiate it from other like diseases. Second, it is important to know what is the best way to treat the problem under existing knowledge.

Odd cases of white-muscle disease can easily be confused with arthritis, copper deficiency, tetanus, footscald, and possibly rickets. I think it is important for farmers who have not experienced the disease before, to seek advice before attempting to guess at a diagnosis and employing expensive treatments. I feel that, due to increased publicity of the disease, there is a tendency for farmers to become apprehensive about the disease and in so doing overlook the actual problem which needs remedying in their flocks.

For example, I can call to mind last season a farmer who had experienced white-muscle disease in previous seasons in varying degrees, and as a precaution had drenched all lambs at weaning with 500 mg of Vitamin E in oil at about ninepence to a shilling a dose. (This at the time was possibly quite a reasonable procedure.)
later stage he still thought he had white-muscle disease. When I visited his farm post mortem of lambs suspected as having white-muscle actually showed them to be cases of bone fragility as a result of very severe copper deficiency later confirmed by liver analysis at Wallaceville Research Station.

Further, it is not the odd cases showing white-muscle disease in an extreme condition which I feel are important, but rather I suggest you ask yourself the question, “What does the rest of the flock look like?”

This point was well brought home to me last spring when I saw two flocks of about 500 lambs on one particular property each with about 40 per cent of lambs affected with a severe ill-thrift, and these were “potential diers” unless some treatment was initiated smartly. Samples (post mortems) from this flock revealed that white-muscle was present. Most of the unthrifty lambs were tucked up, not feeding, reluctant to move, and hanging round water races.

At this stage selenium as a therapeutic agent was an unknown quantity. I favoured large oral doses of tocopheryl acetate (Vitamin E) as I had had good responses in the past. However, one flock of 480 lambs was injected with one mg. of sodium selenate and the rest were dosed with 500 mg. Vitamin E in oil.

The change in these unthrifty lambs was spectacular. These lambs recovered, and grew, and fattened at a normal rate in spite of a severe drought which covered North Canterbury last spring. The selenium group of lambs was treated a fortnight later with a further dose of one mg.

It is interesting to note that, in some cases of less severe outbreaks of white-muscle ill-thrift, spontaneous recovery does appear to take place after the lambs reach a certain stage. I mean that the mob generally appears to improve in health even though certain lambs may die of the extreme stage of the disease. The spontaneous recovery does not seem associated with feed changes.

This brings us to another point of interest. It would appear useless, in the light of experience, to dose lambs with Vitamin E at tailing time hoping that this will prevent further outbreaks or loss from white-muscle disease. The correct time to use Vitamin E economically is when lambs first show signs of ill-thrift and odd cases of white-muscle make their appearance. As to its use in prevention of white-muscle disease on new born lambs by dosing ewes, I think more work is required and probably selenium would give better and cheaper control in these cases. Re-dosing with Vitamin E in an outbreak of white-muscle ill-thrift does appear necessary under certain conditions; likewise, it may be necessary with the use of selenium. It depends upon how rapidly a general recovery is affected. I would not like to lay down any hard-and-fast rule at this stage other than to say, “Seek advice and treat every outbreak of white-muscle according to the picture presented.”

Before passing to consideration of other causes of ill-thrift, may I summarise my main points and stress:

1. White-muscle disease is undoubtedly a particular type of ill-thrift in which a large proportion of lambs in a given flock can be affected without necessarily showing lesions.

2. It is important to seek advice and differentiate the disease from other like diseases in lambs.

3. Use Vitamin E treatment when an outbreak occurs rather than as a preventative used haphazardly at any stage. Selenium may give a longer and more reliable measure of protection.

Leaving white-muscle disease and passing to other types of ill-thrift, particularly ill-thrift affecting sheep from weaning to maturity, I would like to briefly summarise the following as important.

(a) Without doubt, internal parasites of sheep (particularly the worms found in the abomasum or fourth stomach of sheep, i.e. Hae-
monchus contortus, Ostertagia a Trichostrongylus) are, as far as my investigations are concerned, one of the prime causes of some of the so-called mysterious ill-thrift. I admit they are sometimes secondary in importance, but in many cases after strategic drenching with good-quality phenothiazine, followed by improved management, particularly rotational grazing, poor-quality lambs often recover and fatten in a few weeks. This happened even last season when, due to the prolonged drought, fat-lamb feed was extremely scarce in North Canterbury. The farmer that drenched several times and used his feed judiciously, fattened lambs at approximately the same time as usual. Too often the picture is one where the farmer uses his best feed on worm-infected lambs and then tries to fatten them late in the season when the best fattening feed has been lost.

**TABLE 1**

<table>
<thead>
<tr>
<th>Copper</th>
<th>Copper deficient</th>
<th>Copper borderline</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of farms examined</td>
<td>No. of livers, i.e., less than 25 ppm.</td>
<td>25 ppm. to 90 ppm.</td>
</tr>
<tr>
<td>107</td>
<td>284</td>
<td>49 on 26 properties</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 on 13 properties</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cobalt</th>
<th>Cobalt deficient</th>
<th>Cobalt borderline</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of farms examined</td>
<td>No. of livers, less than 0.09 ppm.</td>
<td>0.1 ppm.</td>
</tr>
<tr>
<td>104</td>
<td>215</td>
<td>10 on 8 properties</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11 on 10 properties</td>
</tr>
</tbody>
</table>

A second aspect of the ill-thrift problem which I wish to review briefly with respect to North Canterbury is copper deficiency and/or copper-molybdenum imbalance. This is not necessarily a major problem in North Canterbury but it is an interesting one and, in spite of numerous articles in agricultural journals and papers, generally it tends to be treated casually.

When it comes to trace-element diseases it is dangerous to stick strictly to certain figures as being the last word, when such and such happens to stock.

For example, a liver of a sheep analysed as having less than 20 ppm. of copper is copper deficient, and one with 40 ppm. of copper is not copper deficient. Both, to my mind, indicate a deficiency. Likewise, sheep possibly suffering from a copper deficiency may also be starved and heavily infected with parasites.

I would rather prefer a certain amount of elasticity in any figures and evaluate them on the results of the corrective measures applied. In other words, it is often necessary to apply a treatment to diagnose a trace-element deficiency clearly.

From Table 1 it can be seen that of 284 livers examined in 107 farms, 49 were found to be copper deficient on 26 farms and 20 borderline on 13 farms. With regard to cobalt, ten livers from eight farms were deficient, 11 from ten farms were borderline. Liver analysis for cobalt deficiency may not always detect a deficiency.

I would like to stress that the classical symptoms of copper deficiency, e.g., sway-back, steely wool, and so on, were not seen on all these farms by any means.

Probably the commonest extreme symptom seen is spontaneous bone fracture in both young lambs at four to six weeks and in hoggets in May and June. The latter is invariably associated with a general ill-thrift in the mob, and diarrhoea. This class of symptom I have found usually occurs in one particular area where pasture molybdenum is naturally high (often greater than five ppm.) and copper
TABLE 2
Copper and molybdenum levels of a previously non-copper deficient farm heavily topdressed with Mo-superphosphate 8-10 oz. to the acre.

<table>
<thead>
<tr>
<th>No. of paddock</th>
<th>Copper level (N)</th>
<th>Mo level (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.7 ppm.</td>
<td>5.8 ppm.</td>
</tr>
<tr>
<td>2</td>
<td>6.5 ppm.</td>
<td>7.2 ppm.</td>
</tr>
<tr>
<td>3</td>
<td>6.0 ppm.</td>
<td>6.3 ppm.</td>
</tr>
<tr>
<td>4</td>
<td>5.8 ppm.</td>
<td>3.6 ppm.</td>
</tr>
<tr>
<td>5</td>
<td>6.5 ppm.</td>
<td>6.2 ppm.</td>
</tr>
<tr>
<td>6</td>
<td>7.1 ppm.</td>
<td>7.6 ppm.</td>
</tr>
<tr>
<td>7</td>
<td>7.2 ppm.</td>
<td>5.6 ppm.</td>
</tr>
<tr>
<td>8</td>
<td>7.3 ppm.</td>
<td>9.9 ppm.</td>
</tr>
<tr>
<td>9</td>
<td>6.5 ppm.</td>
<td>8.5 ppm.</td>
</tr>
<tr>
<td>Mean</td>
<td>6.51 ppm.</td>
<td>6.74 ppm.</td>
</tr>
</tbody>
</table>

tends to be low (four to five ppm.). These symptoms have also occurred on farms heavily topdressed with molybdenum, usually one to two years previously.

An example of how severely molybdenum can effect the copper level of a normal farm is seen in Table 2 where eight to ten ounces of molybdenum was applied with one hundredweight superphosphate. The mean pasture level of molybdenum is higher than copper and puts stock grazing these paddocks in a very precarious position. Fortunately, on this farm the trouble was diagnosed before any outward signs of copper-molybdenum imbalance has occurred and judicious grazing and drenching with copper sulphate has probably prevented possible ill-thrift.

Two examples of farms where extreme bone-fragility and general ill-thrift of mobs of hoggets occurred are shown in Table 3.

TABLE 3
Examples of copper deficiency probably aggravated by molybdenum topdressing.

**Farm A**
Copper level from livers of ill-thrift Hoggetts

<table>
<thead>
<tr>
<th>Copper level N(50 ppm.)</th>
<th>Copper in pasture (N)</th>
<th>Mo.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0 ppm.</td>
<td>(1) 1.7 ppm. (N 10 pp.)</td>
<td>2.0</td>
</tr>
<tr>
<td>5.4 ppm.</td>
<td>(2) 2.1 ppm.</td>
<td>2.6</td>
</tr>
</tbody>
</table>

**Farm B**
Copper level from livers of ill-thrift hoggets

<table>
<thead>
<tr>
<th>Pasture copper Mo.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) 3.1 ppm. N 10 pp</td>
</tr>
<tr>
<td>(2) 2.3 ppm.</td>
</tr>
<tr>
<td>(3) 3.3 ppm.</td>
</tr>
<tr>
<td>(4) 2.2 ppm.</td>
</tr>
</tbody>
</table>

In both cases Mo. applied as a light topdressing of 2 oz. to acre.
The first case was seen in 1955 and the general condition of the hoggets was miserable. Latterly this farmer has applied copper extensively annually and there is a noticeable improvement in his stock, particularly young sheep, and no cases of bone fragility have occurred.

In the second case, also in 1955, not only was a severe ill-thrift seen, coupled with bone-fragility, but there was a definite tendency towards a steely type of wool. In this case stud sheep were involved, but careful drenching with copper sulphate (it had to be careful to avoid loss) effected a slow recovery. This was followed by topdressing with copper at a suitable date. It is interesting to note that on these and other farms where the copper level is affected, annual topdressing is necessary to keep copper levels in pastures at a near-normal level. In six to 12 months, pastures tend to revert to the level of copper prior to topdressing.

A further point of importance is that in most of these cases of copper-molybdenum imbalance, there has been a concurrent high infection of worms, but repeated drenching with phenothiazine and rotational grazing have not effected a cure. They may have helped but it is not till copper has been applied that the sheep start to pick up.

To summarise the copper position in North Canterbury, we can say that both virtual and partial copper deficiencies occur affecting sheep of all ages, but particularly lambs and hoggets. The older sheep found affected have been Merino rams on back-country stations with a possible sterility caused by copper deficiency.

In conclusion, may I say that as far as the hogget ill-thrift position in North Canterbury generally is concerned, I would assess the prime causes to date as being:

(a) Nutritional, i.e., poor feeding and management of existing pastures.
(b) Coupled with heavy parasitic infestation particularly with stomach worms.
(c) Both marginal and virtual copper, or cobalt deficiencies. I would go as far as to say that with existing knowledge (even poor as it is on some of the more complex and ill-defined causes of ill-thrift) much can yet be done with what we already know, and have known for some years, to reduce so-called ill-thrift in young sheep.

(iv) K. G. Haughey, Ashburton.

This contribution to the morning's deliberations will consist of a few very brief observations on white-muscle disease as it occurs in the Ashburton County. In addition a resume will be given of the few primitive steps we have taken to elucidate the problem of ill-thrift in the above County.

At the outset it must be made perfectly clear that the observations apply to the Ashburton County only and we are in no way setting ourselves up as authorities on ill-thrift. There is probably one man only in New Zealand, Mr Ted Clarke, of Ruakura, who has made a contribution to basic knowledge of the ill-thrift complex and I think it is unfortunate in many ways that he is not on this panel this morning. Perhaps we will have the opportunity of hearing something from him later.

A. White-muscle disease in the Ashburton County

(i) Occurrence: The condition was first recognised in hoggets and ewes in 1952. Since that time it has been recorded mainly in young lambs two to six weeks of age and also in hoggets each year, the number of outbreaks varying from year to year. In 1958 62 outbreaks were confirmed by post mortem. We suspect that losses
occurred on many other properties in the area, some of them severe. In addition, on a number of occasions lambs post-mortem for other reasons, e.g. tetanus and pulpy kidney, showed evidence of mild white-muscle heart lesions. Evidence is being collected indicating that lambs born of hoggets and two-tooth ewes are the most susceptible.

(ii) Importance: The condition is probably becoming one of the major disease problems of sheep farming in the area. Last year, the congenital form, lambs born with white-muscle heart lesions, was recognised for the first time. Approximately 60 per cent of 400 lambs born dead or dying soon afterwards, showed extensive involvement of the heart on post-mortem. These lambs were the total deaths after the first losses were recognised on properties experiencing trouble with white-muscle. Thus in addition to the recognised losses from white-muscle in older lambs and hoggets, the congenital form may contribute significantly to perinatal lamb losses, i.e. lambs dying before, during or soon after the birth process.

(iii) Feed Conditions: It has been suggested that the feeding of legumes is associated with white-muscle disease. Examination of the ewe feeding practised in outbreaks involving the congenital type would not necessarily bear this out. Outbreaks occurred under all the common winter feeding regimes practised in the area, namely:

- Turnips with and without hay (lucerne or meadow).
- Saved grass and hay.
- Turnips and grass with and without hay.
- Young grass and hay.

(iv) Trials: Vitamin E and selenium trials have been and are being conducted in collaboration with Wallaceville workers.

B. Ill-thrift in the Ashburton County

The following is an outline of trials that have been conducted on lambs failing to thrive. Again it is necessary to stress that as the observations have been made under the conditions in the Ashburton County they need not necessarily find application in part or in whole, in any other area.

(i) Cobalt: Thirty trials, using cobalt drench or bullets, have been conducted. In three trials only—all in the same year—was a significant response obtained. Two of those three properties experienced severe ill-thrift after top-dressing with cobalt the following year. Low levels of cobalt in livers have been recorded on a number of occasions but cobalt therapy has failed to produce a weight-gain response on these properties. Recently it has been shown that there is sometimes an interaction between selenium and cobalt. This is under active investigation at the moment.

Conclusion: Cobalt deficiency does not contribute primarily to failure of lambs to thrive in the Ashburton County.

(ii) Copper, Cobalt, and Iron: Three trials using this drench have been conducted. In one trial a significant response was obtained but as a similar response was obtained with cobalt alone it was concluded that cobalt was the factor responsible.

(iii) Phenothiazine: Weight-gain responses have been obtained in only two of four trials carried out. As ill-thrift lambs in our area have quite frequently carried low numbers of worms and also because phenothiazine frequently failed to check ill-thrift, it has been concluded that those worm parasites found in the Ashburton County are of secondary importance only in the production of ill-thrift.

(iv) Frantin: Considerable press publicity has been given to an anthelmintic specific for *Nematodirus* infestation of young lambs. Five trials, one of them in conjunction with phenothiazine, involving 430 lambs have been conducted. The results have not been statistically treated but there does not appear to have been any marked
effect. It must be admitted however, that these trials were conducted after what is considered to be the period of trouble with *Nematodirus*. However for the same reason as mentioned with regard to phenothiazine—that unthrifty lambs frequently do not carry heavy worm burdens—it is my opinion that this drug, biphenium embonate or Frantin, will not significantly contribute to the control of ill-thrift. In addition the present cost varying between two to three shillings per dose would mitigate against its use.

(v.) Selenium: It has been recently shown that the administration of selenium to lambs, will sometimes give a growth response. Fortunately for farmers, and unfortunately for ourselves, very few mobs of unthrifty lambs have been available this season. Ten trials have been or are being conducted. Three only of the ten are giving what appears to be a highly significant result. The other seven, although giving a small positive result, do not look very promising. The best that can be said for selenium at the moment, is that it may be useful in controlling some types of ill-thrift, and it is worthy of further investigation. We hope to undertake measurements next year on a larger scale as we now possess an efficient, transportable, sheep-weighing apparatus. Due to its well-known toxic properties we are using selenium only on the basis of a marked positive response in terms of weight gain.

That is a brief report on white-muscle and ill-thrift in the Ashburton County. I regret it is not a very hopeful one with regard to ill-thrift—particularly in view of the economic importance of the condition. The outlook for white-muscle however is considerably brighter. The only facetious advice I can offer at the moment regarding prevention of ill-thrift is “keep Canterbury dry.”

(v) M. C. Armstrong, Department of Agriculture, Timaru.

For the purposes of this contribution, the terms ill-thrift and unthriftiness are synonymous because in practice both are applied to define lambs failing to thrive in varying circumstances and apparently due to different complexities of causes. The intensity of unthriftiness varies greatly from farm to farm within seasons and between seasons. In different lamb flocks it varies greatly from a contrasting tail-end problem to a general effect on all lambs. We have investigated all of these, particularly several severe outbreaks in 1958 in which all lambs were affected and death rates were as high as 50 per cent. Unthriftiness occurred with scouring and without scouring, with appetite and without appetite and with varying levels of blood volume.

**Occurrence in South Canterbury**

Unthriftiness usually occurs in spring and summer and there is a general tendency for affected lambs to improve in the autumn. Outbreaks have been investigated on all classes of soils from heavy downland clay loams to light stony silt and sandy loams.

**On Light Soils**

The most severe losses occurred over large areas of improved stony soils in summer 1957-58. They were limited geographically to stony silt and sandy loams of the following description: Ashwick, Lismore, Steward, Eyre, Paparua stony silt loams, and Pukeuri shallow silt loam. This light-land ill-thrift coincided with a spring and summer of unusually abundant growth of foliage. It was apparent in early November in lambs six to eight weeks of age and became most severe after weaning time. Trouble was experienced on pasture, lucerne, and rape.
On Heavy Soils

On heavy soils the ill-thrift tends to appear in a varying proportion of tail-end lambs before weaning and often at a time when the tops are being drafted as fats. This state of affairs occurs in seasons of plenty as well as in seasons of scarcity. Some severe outbreaks in November with high incidence and big losses have occurred on heavy land where stock density was high. Outbreaks tend to be more severe under set-stocking systems and in the absence of pasture spelling and control by cattle.

Nature of investigations

During the investigations of 70 outbreaks over the past two summers we have recorded information on management and lamb health. Affected lambs were examined clinically and some typical ones killed for post-mortems. Freshly-killed lambs were preferred for true parasite assessments and blood pictures. As a general rule, gut specimens were submitted to the Wallaceville Diagnostic Station for counts of parasites, bacterial examinations, and liver estimates of cobalt and copper.

Numerous trials with cobalt supplement were conducted on all classes of land with particular attention to the areas of severely affected light land in 1958. In three of these trials the benefit of an iron, copper and cobalt mixture was compared with cobalt alone. Since early February this year the Department of Agriculture conducted 44 cobalt trials mainly on heavier, fertile soils where a percentage of unthrifty lambs was more apparent than on the light-land soils where cobalt had been extensively applied.

In addition seven selenium trials have been conducted—three of these on cobaltised light land, two on heavy land, and two on non-cobaltised light land. These last four trials were tests of selenium with and without cobalt.

Findings

1. Copper. Normal levels of liver copper existed on all but two farms where odd livers had moderately-low copper estimates. On one of these farms a copper supplement was of no benefit when used in a trial with and without cobalt.
2. Iron. In three trials with severe ill-thrift on light-land soils in 1958, iron was used in combination with copper and cobalt and no benefit was obtained beyond that derived from cobalt alone.
3. Cobalt. The existence of a seasonal deficiency of cobalt over extensive areas of improved light land during the 1957-58 summer was indicated by low deficiency levels in livers and by results of cobalt trials in unthrifty lambs on various pastures and on rape (Armstrong 1958). Where cobalt deficiency existed, appetites were depressed and blood volumes low.

This occurrence of incipient cobalt deficiency was undoubtedly induced by the rapid abundant growth of foliage on leached soils adequately topdressed with lime and phosphate. No molybdenum had been used on these soils but some had been heavily treated with lime at levels of six tons per acre within six years. No correlation could be established, however, between the severity of ill-thrift and the quantity of lime used per acre during the previous six years. More information is required to show what detrimental effects various levels of pH may have on availability of cobalt in Canterbury soils.

It was shown in two trials that the presence of a moderate deficiency of cobalt can be alleviated by short pasture or sparse grazings where soil contamination of food occurred. Because soil contains about 30 times as much cobalt as pasture, it is considered that the ingestion of soil with short or heavily-grazed pasture provides sufficient cobalt for lambs under moderate deficiency conditions (Andrews et al 1958).
New Zealand observations are that seasons favouring lush growth of pastures tend to cause the development of cobalt-deficiency disease and the cobalt content of pastures tends to decrease in spring and summer and increase in late autumn and winter. The effect is probably a double one due to longer, cleaner pasture with less soil contamination and to a lower uptake of cobalt in rapidly growing plants.

As mentioned previously, 44 cobalt trials have been started in South Canterbury since early February 1959 mostly on heavier soils. No responses have been obtained in any of these trials. Pasture conditions for the first few weeks were short and dry and when growth did occur in March and April it was not rapid, long and lush.

Although extensive seasonal cobalt deficiency was found on light-land areas in 1958 there is no information that the heavier soils are similarly affected in South Canterbury and the role of cobalt on heavy land during lush seasons of growth has to be examined.

4. Selenium. In our seven trials with selenium this year we have recorded small favourable responses in all of them on various soils. Improved weight gains averaging between two and five pounds per head were obtained during the autumn period 14/2/59 to 8/5/59 on ordinary pasture, irrigated pasture and a mixture of turnips and grass. It is pertinent to record that there had been no history of white-muscle disease on any of these farms.

These results, together with those published by McLean et al (1959) and the unpublished information from the Department of Agriculture, suggest that a selenium deficiency may retard the optimum thrift of lambs during the spring, summer and autumn in Canterbury.

5. Nitrogen. On two farms in April 1959 unthrifty lambs were killed that showed chocolate-coloured arterial blood. With these rare exceptions there have been no clinical or post-mortem signs of nitrate-nitrite intoxication associated with outbreaks of ill-thrift. Information is required on the significance of sub-lethal amount of nitrate-nitrite in the ill-thrift complex.

6. Internal Parasitism. In South Canterbury our investigations have shown pathogenic counts of parasites in all severe outbreaks of unthriftiness, and the milder outbreaks of tail-end unthriftiness have been associated with either pathogenic or near-pathogenic counts in all but a few.

The widespread occurrence of unthriftiness on the light-land areas in 1957-58 was a “clean tailed” non-scouring disease in which consistent high counts of *Ostertagia* species of small stomach worms were present. It was found that copper sulphate-nicotine sulphate and ordinary dose rates of phenothiazine were not effective. Good growth responses of lambs followed the removal of *Ostertagia* species by increased dose rates of fine-particle phenothiazine equivalent to one and a half fluid ounces of phenothiazine containing at least 60 per cent of particles under five microns. This gave field confirmation to the experimental work of Thomas and Elliot at Wallaceville (1957). Investigations in the spring, summer and autumn of 1958-59 in 32 outbreaks have shown the presence of significant counts of *Nematodirus* species of intestinal worms in 30 or 94 per cent; *Ostertagia* species were present in significant number in 22 outbreaks or 70 per cent; while *Trichostrongylus* species were significant in 12 or 37 per cent. *Trichostrongylus* species were accompanied by *Nematodirus* and *Ostertagia* as mixed infestations. Dirty tails and scouring occurred where *Nematodirus* or *Trichostrongylus* were significant.

On several properties on heavy land severe early ill-thrift and losses of lambs in November-December were associated with high counts of *Nematodirus* species. Many affected lambs had a secondary bacterial infection by *B. coli* and the combined effects were severe and usually fatal. In the United Kingdom acute *Nematodirus* disease...
causes serious losses and unthriftiness in young lambs from six weeks of age onwards (Scarnell and Rawes 1959). The drug of choice at present is bephenium embonate ("Frantin") which is efficient for both treatment and prevention. The pathogenic significance of Nematodirus infections in New Zealand is not known and trials with phenium embonate are necessary.

Internal parasitism was most severe under conditions of high stock density and where there was inadequate spelling of pastures from sheep. There were many good recoveries from unthriftiness by worm control alone especially on heavy soils. Furthermore, in both our cobalt and selenium trials the maximum and most regular weight gains were obtained in the presence of worm control. The great advantage in weight gains by controlling parasites in addition to the use of cobalt and selenium has emphasised the harmful nature of the so-called secondary parasites.

Recommendations

The use of additional cobalt is indicated on light, stony soils where unthriftiness in lambs has been troublesome. Warm, wet seasons with fast, lush growth of pastures favour incipient deficiencies of cobalt and cobalt trials on other soils are worth repeating during seasons of unusually rapid growth of pasture associated with unthriftly lambs.

The control of internal parasites on pastures in South Canterbury cannot be assured at present by providing known nutritional factors. Satisfactory control should be maintained by spelling pastures, cleaning up with cattle and by the preventive use of fine-particle phenothiazine. Care should be taken not to give phenothiazine to partially dehydrated lambs under dry conditions off dry feed.

Where Nematodirus infestation is suspected before weaning, trials with bephenium embonate are suggested.

No recommendations can be given at the present time for the use of selenium and we intend to continue field trials in the future.

References:


In reviewing the work done on problems of animal health over the last twelve months it is encouraging to us, and should be a source of some satisfaction to the farming community, to be able to report evidence of some progress being made towards the solution of some of the problems confronting us. In this respect, of course, we refer especially to the work done on the use of selenium in the control of white-muscle disease in young lambs and its effects in some districts of promoting growth in young sheep at certain times of the year, and therefore the part that it may play as one factor in the ill-thrift problem.

The idea of using selenium for the control of white-muscle disease in sheep arose from the demonstration by research workers abroad, about two or three years ago, that traces of this element in the ration, of the order of one part in ten million, had high protective powers against necrotic liver degeneration in the rat and mouse and "exudative diathesis" in the chick, when these animals were fed diets deficient in vitamin E and containing a high proportion of torula
yeast. It is greatly to the credit of officers of the Animal Research Division of the Department of Agriculture that so soon after these results were reported, trials were instituted in this country to test its value in controlling white-muscle disease which is a related condition in large animals. From the evidence already available, there is every reason to believe that selenium given to the lambs and probably to the ewes will protect lambs against white-muscle disease, and the only major problem remaining is just how and when to administer it to animals in the required amounts with safety to them and to us. This, you will all agree, is a major problem upon which a great deal more work must be done.

Our work, and that of others to be reported today, on the value of selenium in producing growth responses is a further development of these investigations.

In addition, we have followed other lines of investigation, some with interesting results, which it is now proposed to summarise.

**Topdressing and other trials at Ashley Dene**

One part of this trial consisted of three eight-acre plots of lucerne receiving the following topdressing in the spring: superphosphate alone 1 cwt per acre (control); super plus copper and cobalt; super, copper, cobalt, iron, and magnesium at the rates of 5 oz copper sulphate, 5 lb copper sulphate, 10 lb iron sulphate and 50 lb magnesium sulphate. Thirty-six ewes and their lambs were grazed on each plot from a few days after birth until weaning. In addition, half the lambs on each plot received every ten days injections of iron (130 mg) and vitamin E (300 mg). Live weights were recorded at intervals of 10 to 14 days.

The other part of this trial consisted of an adjoining eight-acre plot, half of which received 5 oz of cobalt sulphate as a spray on 3 October 1958. Groups of 20 ewes and their lambs grazed on each half.

**Results:** In the topdressed plots the incidence of white-muscle disease was low and there was no difference between treatments. There were no differences in the rate of growth of lambs until just towards weaning when the copper and cobalt group showed a slight superiority.

Blood analysis at five and nine weeks of age showed a ten per cent higher level of haemoglobin in those given iron either by injection or topdressing of pasture.

In the other section of the trial involving the two groups of lambs on the cobalt sprayed and unsprayed blocks, seven out of 24 of those on the cobalt treated area developed white-muscle disease.

One month after cobalt treatment started, half of each group was given selenium at the rate of 1.0 mg selenium as sodium selenate by injection on eight occasions at intervals of approximately 10 days. The growth responses up to February are shown in table 1.

**TABLE 1**

<table>
<thead>
<tr>
<th>Mean Live Weight in Pounds</th>
<th>(Lucerne Trial Lambs at Ashley Dene) First Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
</tr>
<tr>
<td>Se plus Co</td>
<td>3/11/58</td>
</tr>
<tr>
<td></td>
<td>2/2/59</td>
</tr>
<tr>
<td>Gain</td>
<td></td>
</tr>
<tr>
<td>Se</td>
<td>41.1 (11)</td>
</tr>
<tr>
<td></td>
<td>80.6</td>
</tr>
<tr>
<td>Co</td>
<td>40.2 (12)</td>
</tr>
<tr>
<td></td>
<td>76.1</td>
</tr>
<tr>
<td>Control</td>
<td>41.7 (10)</td>
</tr>
<tr>
<td></td>
<td>75.2</td>
</tr>
<tr>
<td>Differences in 91 days</td>
<td>41.6 (11)</td>
</tr>
<tr>
<td></td>
<td>62.6</td>
</tr>
</tbody>
</table>

There is a marked response both to selenium and cobalt both of which are highly significant. Further examination of the data showed
that the response to cobalt did not occur until selenium treatment started, and there was little carry-over effect after the lambs were weaned and taken off the cobalt-treated area.

On 2 February 1959 selenium treatment was discontinued to see how long its effects would persist in the absence of selenium supplements. The results are shown in table 2.

**TABLE 2**

**Mean Live Weight in Pounds**

*(Lucerne Trial Lambs at Ashley Dene) Second Period*

<table>
<thead>
<tr>
<th>Date</th>
<th>Treatment</th>
<th>Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/2/59</td>
<td>Se plus Co</td>
<td>80.6 (11) 101.0 20.4</td>
</tr>
<tr>
<td>14/5/59</td>
<td>Se</td>
<td>76.1 (12) 98.9 22.8</td>
</tr>
<tr>
<td></td>
<td>Co</td>
<td>75.2 (10) 96.7 21.5</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>62.6 (11) 86.0 23.4</td>
</tr>
</tbody>
</table>

It will be noted that there is only a partial recovery in the untreated lambs after treatment with selenium was discontinued.

2. **Trials with copper and iron supplements given by injection**

(a) Copper supplements—lambs.

On 1 October 1958 half the lambs (60) in the Corriedale stud flock were injected subcutaneously with 1½ c.c. of the ten per cent solution of "dicuprine"; treatment was repeated with 1.0 c.c. on 28 October 1958. No significant response was obtained; if anything there was a suggestion that the copper tended to suppress growth.

(b) Copper supplements—hoggets.

Because there was some suggestion of "steeliness" in the wool of the stud Romney ram hoggets at shearing in October, a sample of 50 unshorn ewe hoggets was weighed and divided into two groups, one of which was given 5 c.c. of "dicuprine" to see what effect the copper supplement would have on their wool. No effect on wool was observed, but there was evidence of a slight depressant effect on growth rate.

(c) Iron supplements—lambs.

On 16 September 1958 the Border Leicester stud lambs were weighed and randomised into two groups, one of which received an injectable iron compound (Imferon), containing 100 mg of iron, on four occasions at intervals of ten days. No growth response was noted, but blood analyses again showed a slight response in haemoglobin level.

3. **Trials with worm drenches—trials with Bephirinium embonate (Frantin).**

(a) At the College. Because we were led to suspect that the poor condition of some of the stud lambs in early spring might be caused by infestation of *Nematodirus*, a trial was conducted with the new drug called "Frantin" kindly supplied by Burroughs, Wellcome. This drug is specifically designed to control *Nematodirus*, an intestinal worm not readily treated with phenothiazine. Half the Corriedale lambs were drenched with 5.0 g m Frantin twice, at an interval of 14 days. Weight gains are shown in table 3.

**TABLE 3**

**Mean Live Weight in Pounds**

*(Corriedale Stud lambs)*

<table>
<thead>
<tr>
<th>Date</th>
<th>Treatment</th>
<th>Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>24/10/58</td>
<td>&quot;Frantin&quot;</td>
<td>33.9 (63) 48.3 14.4</td>
</tr>
<tr>
<td>21/11/58</td>
<td>Control</td>
<td>35.1 (60) 46.2 11.1</td>
</tr>
</tbody>
</table>

There was a highly significant response to treatment. To get an estimate of the degree of infestation, faecal samples were taken from six lambs in each group. Total egg count rose above 1000 eggs
per gm in only two lambs. *Nematodirus* eggs were between 200 and 600 eggs per gm in the untreated lambs, whereas there was none at all in the “Frantin” treated animals.

The response to treatment is high considering the relatively-low level of infestation as indicated by the egg counts. It must be pointed out, however, that damage to the gut wall may be quite extensive before the worms reach the egg-laying stage.

(b) On an outside farm. One other Frantin trial was conducted on a sample of 40 of a flock of Down-cross lambs, 20 of which were treated. Over a period of 11 days, these maintained body weight while the others lost an average of one pound.

4. Trace-element trials
   (a) The effect of selenium supplements in stud Romney, Border Leicester and Corriedale lambs on the College stud farm.

These trials were commenced during the first week in October. In all cases selenium was given as sodium selenate by injection at the rate of 1.0 mg selenium every 10 days. The lambs were weaned in the first week of December and shorn on 18 December, after which the sexes were separated, the males going on to supplementary crops and the females on to pasture. Prior to treatment, the “thrift” of the Romney and Border Leicester lambs could be described as only fair, and that of the Corriedale as poor. The results are summarised in table 4.

| TABLE 4 |
| Mean Live Weights and Gains in Pounds for Pure-bred Romney, Border Leicester and Corriedale Lambs |
| Romney | Date | Selenium | Control | Difference in 105 days |
| 9/10/58 | 22/1/59 | 30.5 (84) | 31.5 (88) | 4.1 |
| Border Leicester | Date | Selenium | Control | Difference in 95 days |
| 19/10/58 | 22/1/59 | 51.2 (49) | 56.3 (47) | 6.4 |
| Corriedale | Date | Selenium | Control | Difference in 62 days |
| 21/11/58 | 22/1/59 | 46.6 (61) | 47.4 (59) | 3.0 |

It will be seen that the responses of the order of 12 to 30 per cent were observed. Intervening weights show that differences first appeared two to three weeks after treatment started and increased gradually up to the last weighing.

(b) Other trace-element trials on the Stud Farm.

In October the stud Corriedale lambs and ewes on the N.W. block of the Stud Farm showed signs of ill-thrift. This is the earliest that we have observed the condition. They were removed from this area and a trial was commenced on it, using 100 forward store Corriedale wether lambs from Ashley Dene weaned at nine weeks of age. These were ear-tagged, weighed and randomised on a weight basis into five groups of 20. These five groups were treated as follows:

- Group I—given selenium by injection at the rate of 1 gm of selenium as sodium selenate every 10 days.
- Group II—given manganese-zinc mixture by mouth, at the rate of 50 mg zinc and 25 mg manganese per day.
- Group III—given cobalt as a “bullet.”
- Group IV—control.
- Group V—regional or area control.
Half of each group were treated with phenothiazine every three weeks except during the dry period of January-February.

Groups I to IV were run together in the “suspect” paddock while Group V was put on a paddock on the heavy land in the S.E. block of the College farm. Weighings were made at appropriate intervals. Some “sheath-rot” was observed. Growth rate was good in the early stages, but was slowed down later by the drying off of pastures. Table 5 sets out the data from October, when the trial started, to April this year.

**TABLE 5**

*Mean Live Weight in Pounds (Ashley Dene wether lambs on Stud Farm)*

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Date 11/11/58</th>
<th>Gain in 93 days</th>
<th>Date 15/4/59</th>
<th>Gain in 155 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selenium</td>
<td>52.2 (20)</td>
<td>74.5</td>
<td>86.9</td>
<td>34.7</td>
</tr>
<tr>
<td>Zn plus Mn</td>
<td>52.5 (19)</td>
<td>72.7</td>
<td>83.9</td>
<td>31.4</td>
</tr>
<tr>
<td>Cobalt</td>
<td>52.4 (20)</td>
<td>69.7</td>
<td>82.8</td>
<td>30.4</td>
</tr>
<tr>
<td>Control</td>
<td>52.2 (20)</td>
<td>67.8</td>
<td>80.8</td>
<td>28.6</td>
</tr>
<tr>
<td>Control (area)</td>
<td>51.5 (19)</td>
<td>81.3</td>
<td>93.8</td>
<td>29.8</td>
</tr>
<tr>
<td>Phenothiazine</td>
<td>51.6</td>
<td></td>
<td>83.8</td>
<td>32.2</td>
</tr>
<tr>
<td>Control</td>
<td>51.1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There are several significant features about these results. Considering the first period of 93 days during which the “area” control group was present, it will be observed that there is once again a response to selenium of the order of 43 per cent, which is highly significant.

In addition to this, however, there is evidence of a response to the zinc and manganese mixture of the order of 30 per cent, which is significant at the five per cent level only. This result must therefore be accepted with caution. If real, it is the first time that we have observed such a response. And, of course, there is no evidence as to whether it is due to the zinc or the managanese or the sulphate, or how it functions. At the very least, it is interesting and suggestive. There is no response to cobalt; this is not unexpected since the whole area had been topdressed with cobaltised super in the early spring.

It will be seen, also, that the “area” control group, on another part of the farm, gained almost twice as much as the “treatment” controls, and significantly more than the selenium-treated group. This result is difficult to interpret; it does imply however that even the selenium-treated animals were not growing as fast as they were potentially able to grow.

Turning now to the gains up to 155 days, it is evident that phenothiazine has produced little or no effect. In the other treatment groups, at this stage, the variability of the live weights is so great that, with the relatively small numbers involved, no significant differences can be established statistically. The order however remains substantially the same as at 93 days.

A careful analysis of the variability of the live weights in the four treatment groups, however, brings to light a piece of information that may be of paramount importance. This is shown in the curves of frequency distribution giving the range of gains in live weight for each treatment group. It will be seen that this range is smaller in the group given selenium. (Standard deviations for the four groups are selenium 4.1, cobalt 6.9, zinc and manganese 7.5, and control 9.0). Selenium appears to have had the effect of eliminating the “tail” or poor “doers” in the group, and theoretically, at least, it is possible to argue that, in this respect, it is operating to overcome one of the basic factors in ill-thrift.
(c) Other selenium trials in which no significant responses were obtained.

Two other short-term trials with selenium were conducted, one at Ashley Dene on 70 "tail-enders" from the fat lamb flock, and another at the College on 53 good quality lambs out of Romney-Border Leicester-cross ewe hoggets. In both of these, while the results were in favour of the selenium-treated animals, the differences were not statistically significant.

It was rather unexpected to find no response to selenium in the "tail-enders" from Ashley Dene since this group might have been expected to contain a fair sample of lambs sub-clinically affected with white-muscle disease.

(d) Outside farms.

(i) Hororata. This trial was conducted on a sample of 59 weaned Down-cross lambs from a flock with a history of ill-thrift, and evidence of trouble at the commencement of the trial. The sample was divided into four treatment groups as follows: selenium plus cobalt, selenium, cobalt, and control; cobalt as a bullet, and selenium as selenate by mouth. Table 6 sets out the relevant data.

**TABLE 6**

<table>
<thead>
<tr>
<th>Mean Live Weights and Gains in Pounds</th>
<th>(Down-cross lambs—Hororata)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Treatments</strong></td>
<td><strong>Date</strong></td>
</tr>
<tr>
<td>Se plus Co.</td>
<td>4/12/58</td>
</tr>
<tr>
<td>Se</td>
<td>8/1/59</td>
</tr>
<tr>
<td>Co</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>Difference in 35 days with cobalt</td>
<td></td>
</tr>
<tr>
<td>without cobalt</td>
<td></td>
</tr>
</tbody>
</table>

The overall difference in favour of selenium of 3.5 lb is highly significant. Cobalt has produced no significant positive effects. White-muscle disease has been reported on this property.

(ii) Halkett. This trial was conducted on a sample of the less thrifty lambs in a flock of 900, after 500 had been sold to the freezing works as fat.

Four groups of 25 were taken for the following treatments: Selenium, cobalt, "tissue suspension," and control. Selenium was given by injection at the rate of 2 to 5 mg selenium as sodium selenate every seven days, cobalt as a bullet, and the "tissue suspension," consisting of an especially prepared extract of the spleens of "healthy" animals, was injected at the rate of 5 c.c. every seven days. The results are shown in Table 7.

**TABLE 7**

<table>
<thead>
<tr>
<th>Mean Live Weights in Pounds</th>
<th>(Down-cross lambs—Halkett)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Treatments</strong></td>
<td><strong>Date</strong></td>
</tr>
<tr>
<td>Se</td>
<td>10/2/59</td>
</tr>
<tr>
<td>Co</td>
<td>24/3/59</td>
</tr>
<tr>
<td>Tissue extract</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>Difference in 42 days due to selenium</td>
<td></td>
</tr>
</tbody>
</table>

It will be seen that, once again, there is an appreciable response to selenium. Cobalt or "tissue extract" showed no effects. This flock had no history of white-muscle disease.
(iii) Kaiapoi. In a flock near the coast in this district, trouble has been experienced over a number of years in fattening and rearing lambs. Since at the time of inspection, there was evidence of bone fragility, all lambs were put on to copper supplements. Lambs were ear-tagged, weighed, and four groups established for the following additional treatments: selenium, as selenate by injection at the rate of 2 to 5 mg per seven days, cobalt as a bullet, "tissue suspension" by injection at 5 c.c. per week, and control.

Results for the first 42 days of the trial are shown in table 8.

TABLE 8
Mean Live Weights in Pounds
(Cross-bred lambs—Kaiapoi) First Period

<table>
<thead>
<tr>
<th>Treatment</th>
<th>5/2/59</th>
<th>19/3/59</th>
<th>Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Se</td>
<td>42.4 (35)</td>
<td>54.5</td>
<td>12.1</td>
</tr>
<tr>
<td>Co</td>
<td>44.4 (35)</td>
<td>50.3</td>
<td>5.9</td>
</tr>
<tr>
<td>Tissue ext.</td>
<td>42.8 (35)</td>
<td>49.5</td>
<td>6.7</td>
</tr>
<tr>
<td>Control</td>
<td>43.3 (35)</td>
<td>51.6</td>
<td>8.3</td>
</tr>
</tbody>
</table>

The growth rate in the group given selenium was significantly higher than that of all the others and once again the variability is reduced (S.D. 2.8 as against "Tissue" 5.4, Cobalt 5.5 and Control 3.8). If anything, the cobalt and tissue-extract groups were a little worse than the controls.

In view of the fact that there was a considerable "tail" in these groups, some lambs losing weight, with six actual deaths, it was decided after a trial period of six weeks to change the treatments on 19 March 1959 by giving selenium to both the cobalt and tissue-extract groups. The response to this change is shown in table 9.

TABLE 9
Mean Live Weight in Pounds
(Cross-bred lambs—Kaiapoi) Second Period

<table>
<thead>
<tr>
<th>Treatment</th>
<th>19/3/59</th>
<th>11/5/59 in 33 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plus Se</td>
<td>54.5 (35)</td>
<td>63.3</td>
</tr>
<tr>
<td>Co plus Se</td>
<td>50.3 (35)</td>
<td>59.9</td>
</tr>
<tr>
<td>&quot;Tissue&quot; plus Se</td>
<td>49.5 (35)</td>
<td>58.6</td>
</tr>
<tr>
<td>Control</td>
<td>51.6 (35)</td>
<td>57.4</td>
</tr>
</tbody>
</table>

The superiority of the selenium-treated group is maintained by continued treatment. In addition there is a marked response to selenium in the other two groups. There is no known history of white-muscle disease on this farm.

In view of the fact that copper supplementation of the diet, in the form of copper sulphate in the drinking water, had been instituted prior to our inspection of the flock, it was regarded as of little value to include a special group, to study the possible influence of copper on growth rate. In this respect however, it is of interest to note that while signs of bone fragility disappeared with copper treatment, the growth of the "control" lambs and those in the cobalt and tissue-extract groups continued to be low until selenium treatment was started.

5. Ill-thrift trials with short and long pasture

Two trials, one in the spring and another in the autumn, involving the grazing of short and long, and different kinds of pasture, with and without nitrogen topdressing and with and without selenium and cobalt, have been conducted in co-operation with Dr Watkin and his staff of the Grasslands Section of D.S.I.R. at Lincoln.

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(a) Spring trial. The trial area consisted of 96 plots, each of one-twelfth of an acre, approximately two-thirds of the number in ryegrass-white clover dominant pasture, and the other third in legume dominant pasture, mainly lucerne. Prior to starting and during the trial period, the required pasture length was maintained by the use of a mower; that is, half the ryegrass-white clover plots were maintained short and the other half long.

The trial stock comprised 66 mixed sex, Southdown and Dorset Down cross good-quality lambs from Ashley Dene farm weaned at nine weeks of age. They were divided into three groups of 22 for the three types of grazing—long, short and legume—and half of each group was given a cobalt “bullet.” Each group was shifted to a new plot daily.

Pasture production was high during the early part of the trial period but fell off towards the end with the onset of dry weather. Live weight gains are shown in table 10.

**TABLE 10**

Mean Live Weight in Pounds
(CRD—Spring Trial)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Date</th>
<th>Gain in 82 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short Pasture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cobalt</td>
<td>22/10/58</td>
<td>53.0 (11)</td>
</tr>
<tr>
<td>Control</td>
<td>12/1/59</td>
<td>54.1 (10)</td>
</tr>
<tr>
<td>Long Pasture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cobalt</td>
<td>22/10/58</td>
<td>53.1 (11)</td>
</tr>
<tr>
<td>Control</td>
<td>12/1/59</td>
<td>53.9 (10)</td>
</tr>
<tr>
<td>Legume Pasture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cobalt</td>
<td>22/10/58</td>
<td>52.8 (11)</td>
</tr>
<tr>
<td>Control</td>
<td>12/1/59</td>
<td>54.1 (10)</td>
</tr>
</tbody>
</table>

(Note: Cobalt was given on the 5th November.)

The most remarkable feature of this trial is the obvious response to cobalt in the groups on short and long pasture and its absence in the lambs grazed on lucerne and clover. The cobalt response on this class of land at this time of the year is rather unusual. Its absence in the legume group can perhaps best be explained by the fact that the cobalt content of lucerne is usually higher than that of grass under the same conditions.

The growth rate of the lambs on the legume-dominant plots is significantly higher than in the other two groups. This is believed to be due to the fact that, throughout the whole of the trial period, there was more feed on these plots. Towards the end, production on the short pasture tended to fall away, and the growth on the long pasture plots became stalky and unpalatable. No differences have been produced by the two different lengths of grazing.

On inspection of this trial in spring, during a field day at the College, some farmers seemed rather critical of its design, apparently in that we were experimenting with good lambs, on good pasture under unusual conditions. The conditions, it is true, were unusual in that the lambs were shifted daily on to clean feed, but it must be remembered that by definition “ill-thrift” is a “failure to thrive in the midst of plenty,” and so far as we are aware, this is the very thing that farmers complain about—in other words, that it should occur in good healthy lambs.

On 17 December 1958 half of each group of lambs was given selenium by mouth. Over the next 26 days, during which growth was slow, there was no evidence of a response to selenium.

(b) Autumn trial. Because of the dry weather in January and February the spring trial was terminated and the plots spelled,
awaiting the autumn growth. With rain, following the long, warm, dry spell, there was a most unusual flush of pasture growth resembling in degree the kind of thing that happens in parts of the North Island under similar circumstances, with which ill-thrift is so closely associated there.

In view of the association shown in the North Island between ill-thrift and a high non-protein-nitrogen (NPN) content of "flush" grass, it was decided to modify the design of the autumn trial to see if we could establish a similar association here. Pasture samples were taken for nitrogen analysis by D.S.I.R. workers, and in order to increase the uptake of nitrogen, half the mixed pasture plots were topdressed with ammonium nitrate at the rate of two hundredweight per acre on two occasions at an interval of 21 days. Grazing treatments were thus, mixed grass and clover pasture with and without nitrogen topdressing, and legume pasture. Three groups of 16 ewe lambs, of which eight in each group were given selenium, were run on the different treatments. The results are shown in table 11.

### TABLE 11

<table>
<thead>
<tr>
<th>Date</th>
<th>Gain</th>
<th>Total Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legume</td>
<td>70.5 (16)</td>
<td>83.0</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>69.0 (16)</td>
<td>75.5</td>
</tr>
<tr>
<td>Control</td>
<td>70.2 (16)</td>
<td>76.4</td>
</tr>
<tr>
<td>Selenium</td>
<td>69.9 (24)</td>
<td>78.6</td>
</tr>
<tr>
<td>Control</td>
<td>69.9 (24)</td>
<td>78.0</td>
</tr>
</tbody>
</table>

The nitrogen analyses are not yet available. The only significant difference is the superiority of the legume group over the last 25 days of the trial. This is attributed once again to the greater quantity of available "attractive" feed on these plots during the second round of grazing after the second nitrogen topdressing. The grass plots did not recover well after the first grazing and with the wet weather and high stocking rate the feed could not be regarded as attractive. Although the weights are in favour of the selenium-treated animals, the differences are not significant.

From the point of view of the pasture N.P.N. study, while the conditions at the beginning of the trial were propitious, in that growth conditions were favourable, later on, with the onset of cold nights and wet, cold weather, they were rather the opposite of those necessary to maintain rapid pasture growth and circumstances likely to lead to a high N.P.N. content of the grass.

There is in the data no indication that nitrogen topdressing depressed growth in the lambs; if anything, the effect in the early part of the trial period, has been in the opposite direction.

### Summary and Discussion

At this stage you may well ask "What does all this signify?" It is necessary therefore to summarise the results and try to place them in some sort of perspective from the point of view of the problem of ill-thrift.

### Iron Trials

In trials in which iron, as iron sulphate, was applied to the soil with other materials, and as available iron to the animal by injection and by mouth, we have not been able to show any beneficial effects other than a slight rise in haemoglobin levels in the blood. As a factor in ill-thrift under our conditions, therefore, we can only conclude that it is unimportant. Since we had little white-muscle disease
in the sheep treated with iron, we have no evidence of its value in the control of this disease.

Copper Trials
The limited trials with injectable copper given to young lambs showing early signs of ill-thrift, indicate that a deficiency of copper is not a factor in ill-thrift under our conditions. In hoggets also no growth responses were obtained, nor was any effect on the wool observed.

Zinc and Manganese Trials
Concerning our results with the zinc and manganese mixture, we would prefer at the moment to say very little; they may not even be real ($P < 0.5$). We believe however that they warrant further investigation.

“Frantin” Trials
Our limited trials with this drug indicate that *Nematodirus* can be responsible for a slight depression in growth rate in young lambs in the spring. This is an interesting observation, in that rarely do other parasites affect the growth of lambs at such a young and tender age.

Short and Long Pasture and High NPN Trials
In the spring trial this year we were not able to show any difference in thrift between lambs grazing short and long pasture, and there was a cobalt response on both the long and short pastures.

Nor were we able to demonstrate a depression of growth on pasture designed to have a high-nitrate content in the autumn. This does not mean that high-nitrate pasture is not an important factor in ill-thrift as we see it in the South Island, both in the spring and the autumn. Field tests with diphenylamine and chemical analysis of pasture showed high-nitrate levels in both spring and autumn grass, during periods when ill-thrift was a problem, and we believe that work along these lines must be extended.

Cobalt Trials
As far as cobalt is concerned, we have obtained responses of a significant degree this season on the light, shingly soils of Ashley Dene and on the medium-to-heavy cropping land of the Crop Research Division at Lincoln. Whether this is likely to occur every year, under different seasonal conditions, we do not know.

From the results of other workers it seems pretty clear now that this kind of “marginal” cobalt-deficiency exists at least over large areas of Canterbury, and may be over much of the South Island. It sets an upper limit to growth rate in young sheep in some seasons only, and perhaps only on certain types of pasture, and yet is insufficient in degree to produce overt signs of classical cobalt-deficiency except in a small proportion of the flock, that is the “tail-end.” Marginal cobalt-deficiency would seem to be therefore one of the important factors in the overall problem of poor-thrift in this area.

Our results this year show fairly clearly that obvious depression of growth does not take place until November or when the lambs have reached about 10 to 12 weeks of age. Whether this critical time is related to the cobalt content of pasture or to the requirement of the growing animal is not clear. Apparently, it is not often required before this, and this may be an important factor in determining the best time to apply cobalt supplements, in that the most effective and economical use may be made of it when it is applied as a spray to the pasture in late spring.

It has been authoritatively stated that such marginal cobalt deficiency cannot be established by chemical analysis of pasture or liver, and that the only certain way is to observe the response in the growing animal to cobalt supplements. Farmers have therefore been
recommended to conduct trials of their own with cobalt “bullets” before applying remedial measures. While this is an excellent procedure, it obviously has certain limitations. It cannot easily be carried out on unweaned lambs; in weaned lambs it takes about two months to find out, and in this time considerable losses may be sustained, and responses may be obtained only on certain paddocks and in some seasons. What is the farmer therefore to do?

In the meantime—until more is found out about the nature and extent of seasonal changes in chemical composition of pasture with regard to cobalt—a more practicable procedure would seem to be the application of remedial measures when the condition of young stock, pasture or liver analyses, and local knowledge and professional advice suggest that a marginal cobalt-deficiency is likely to exist. If the stock still do not thrive, one possible cause has been eliminated, at little expense, and no harm has been done.

Selenium Responses

Now what is the situation regarding selenium? In eight out of 11 trials covering over a thousand lambs, growth responses have been observed. In two short-term trials the weights were in favour of selenium, but the differences failed to reach significance. In one trial no response whatsoever was obtained.

When responses occurred there was evidence of increased live weight in most cases in two to three weeks. The degree of response was variable, increased gains ranging from 12 per cent to about 40 per cent. Some of these differences were easily seen on inspection, in that the treated animals appeared bigger, cleaner about the tails, and healthier. Further, some of these responses have been obtained in flocks where there has been no known history of white-muscle disease.

This remarkable effect of selenium has as yet no easy explanation. There seems little doubt now that traces of this element are required by the animal for the maintenance of normal growth and health, that the action of selenium within the body is closely related to the function of vitamin E, and that vitamin E cannot completely replace the need for selenium. One way of explaining the growth responses, therefore, is on the basis of a specific selenium-deficiency in the soil and pasture, one indication of which is a slowing up in growth rate, and another a tendency towards white-muscle disease and possibly other conditions in which the activity of vitamin E is concerned. And this, of course, brings up the question of its possible effects in overcoming the “dry” ewe problem.

Unfortunately, at present we know practically nothing about the selenium content of soils and pastures in New Zealand, or of the uptake by our pasture plants of selenium applied to the soil, or its relation to other elements in our soils. There is some evidence of a relationship between white-muscle disease and thyroid activity in some animals, and this might well be related to the association of iodine deficiency and goitre in some of our areas of ill-thrift and white-muscle disease. We do not know.

We do know, however, that selenium is highly toxic both to animals and man when given in more than extremely small amounts. In our opinion this feature cannot be over-emphasised.

It is only natural that farmers should desire to test the value of this element on their own farms, particularly when they are confronted with major problems of infertility, white-muscle disease, or ill-thrift, in each and all of which we have reason to believe that it may prove beneficial, and it is only right that they should have the opportunity to do so. But in view of its known toxicity and the fragmentary knowledge that we have as yet about its effects, it is our very strong view that, until more is known, all trials involving the use of selenium should be carefully supervised by responsible, trained personnel, and designed in such a fashion that useful information to all can be obtained in the shortest possible time.
Just what part selenium “deficiency” plays in the overall picture of ill-thrift in this district is certainly not yet clear. That it could be a factor of some importance is indicated, we believe, by the results presented here today.

(vii) A. B. Grant, C. Drake, W. J. Hartley, Wallaceville Animal Research Station.

For a number of years white-muscle disease has been considered to be due to a vitamin E deficiency because of the similarity of the pathological changes to those seen in certain forms of vitamin E deficiency in small laboratory animals.

Vitamin E preparations therefore have been used extensively in the treatment of white-muscle disease. However, in the absence of controlled trials it is not easy to evaluate critically the results obtained.

Many farmers have claimed great benefit from vitamin E used in treatment of affected lambs; others have not been so impressed. All are agreed however that vitamin E is useless for the treatment of white-muscle disease in hoggets following driving. Further, pre-lambing medication of ewes with atocopherol does not prevent the development of either the congenital or delayed forms of white-muscle disease in lambs. However, atocopherol-treatment of lambs at docking will reduce the incidence of the delayed form of white-muscle disease.

Within the last two years workers in the U.S.A. have shown that selenium will entirely prevent certain disease entities in small animals previously thought to be due to a simple Vitamin E deficiency. Following on these reports workers from Wallaceville last season carried out field trials to observe the effect of selenium in the control of white-muscle disease in lambs.

Mobs of lambs on properties which had previously experienced white-muscle disease were divided into three equal groups at docking. One group received vitamin E, one group received selenium and the other received no treatment. White-muscle disease appeared in 11 of the 16 trial properties, but in no instance were there severe outbreaks. Table 1 shows that vitamin E had some effect in controlling white-muscle disease whilst selenium almost completely prevented it.

Treatment trials with selenium on lambs actually affected with white-muscle disease have not yet been carried out, so we do not know whether selenium will replace atocopherol in the treatment of white-muscle disease.

TABLE 1
Selenium and White-muscle Disease
Cases of White-muscle Disease

<table>
<thead>
<tr>
<th>Selenium Groups—2</th>
<th>Vitamin E Groups—21</th>
<th>Controls—50</th>
</tr>
</thead>
</table>

Hogget Ill-thrift

Hogget ill-thrift is the name given to an ill-defined condition in which lambs fail to thrive in the presence of abundant, apparently highly-nutritious pasture. It is seen in two forms. One form occurs anytime from November onwards and is seen in both islands. It is usually relatively insidious in onset, may be spread over several months and has a variable mortality. The other form characteristically occurs in the North Island after the warm, early-autumn rains and appears to be directly associated with unattractiveness of the fresh growth of grass.

The known causes of the former type of ill-thrift are cobalt deficiency and internal parasites. The major contributing cause is
not yet known, but preliminary investigations indicate that this may in part be due to selenium deficiency.

One of the most severely affected areas experiencing the insidious form of ill-thrift is the newly-brought-in clover-dominant pumice country in the centre of the North Island. As white-muscle disease was recently reported in this area we explored the possibility of selenium alleviating this ill-thrift. Controlled trials were instituted in January 1959 on eight badly-affected farms in the Rotorua-Wairakei area where farmers had lost from 10 to 40 per cent of their lambs since docking.

Table 2 shows the average live-weight increase over a ten-week period of the selenium-dosed lambs in comparison with the controls. It is seen that, on all properties, the selenium-dosed lambs gained more weight than the controls; further, the death rate in the selenium groups was one third of that in the controls.

These trials clearly indicate that selenium both quickly and effectively controlled outbreaks of ill-thrift in the Rotorua-Wairakei area.

As a result of these observations we extended our investigations to the southern half of the North Island, where there was much ill-thrift but where white-muscle disease had not been recognised. Controlled selenium trials have been conducted on 20 properties in the Wellington, Wairarapa and Manawatu provinces during the last three months. The results were similar to but usually less spectacular than those seen on the pumice soils.

In the only trial carried out to date, selenium therapy did not prevent the development of the autumn-flush type of ill-thrift.

To sum up. Our preliminary investigations have shown that selenium is at present the drug of choice in the prevention of white-muscle disease in lambs, and has controlled outbreaks of ill-thrift in hoggets on pumice and other light soils.

### TABLE 2

<table>
<thead>
<tr>
<th>Farm</th>
<th>Selenium groups</th>
<th>Controls</th>
<th>Weight Gain</th>
<th>Deaths</th>
<th>Weight Gain</th>
<th>Deaths</th>
<th>Difference/lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22.3</td>
<td>18.5</td>
<td>3</td>
<td>3</td>
<td>14.8</td>
<td>3</td>
<td>3.8</td>
</tr>
<tr>
<td>2</td>
<td>21.0</td>
<td>13.1</td>
<td>3</td>
<td>7</td>
<td>10.3</td>
<td>8</td>
<td>3.7</td>
</tr>
<tr>
<td>3</td>
<td>14.0</td>
<td>10.3</td>
<td>1</td>
<td>4</td>
<td>3.6</td>
<td>0</td>
<td>14.0</td>
</tr>
<tr>
<td>4</td>
<td>17.6</td>
<td>3.6</td>
<td>0</td>
<td>4</td>
<td>14.1</td>
<td>15</td>
<td>10.8</td>
</tr>
<tr>
<td>5</td>
<td>15.6</td>
<td>4.3</td>
<td>2</td>
<td>14</td>
<td>4.8</td>
<td>15</td>
<td>7.2</td>
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<tr>
<td>6</td>
<td>11.5</td>
<td>4.3</td>
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<td>4.8</td>
<td>15</td>
<td>10.4</td>
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<tr>
<td>7</td>
<td>25.0</td>
<td>14.1</td>
<td>2</td>
<td>3</td>
<td>19.6</td>
<td>5</td>
<td>10.0</td>
</tr>
<tr>
<td>8</td>
<td>29.6</td>
<td>19.6</td>
<td>1</td>
<td>5</td>
<td>19.6</td>
<td>5</td>
<td>10.0</td>
</tr>
<tr>
<td>Total Deaths</td>
<td>19</td>
<td>59</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q.: What should we do when we first experience trouble?

Mr Hartley: My advice is that in November-December or as soon as it starts, contact the Department of Agriculture and explain to them just what is happening. Trials could be carried out using cobalt, phenothiazine and selenium in mobs of not less than 25 lambs, weighing them at the commencement of the experiment and then a month later to note any effects. If there is response go in and treat accordingly.

Q.: Have you any information whether selenium is an impurity in sulphur as it is made available to us commercially, or whether it is an impurity in any other form of manurial supply?
Mr Hartley: The sulphur mined in certain parts of the world contains selenium as an impurity, but I gather that the sulphur that we import from Louisiana in America does not.

As regards other products, we will not be able to answer that question until we have a reliable method of analysis for selenium, which may take a few more months yet.

Q.: Seeing that selenium is very closely related to sulphur chemically, is it possible that in applying sulphur or superphosphate we may be displacing selenium in the soil and causing ourselves trouble?

Mr Hartley: Unfortunately I am not a chemist. But there are definite reports in literature that sulphate will inhibit the uptake of selenium by plants. I have not seen the actual experimental results on that but I have seen it referred to in literature and that could possibly account for the widespread incidence of ill-thrift and white-muscle on farms where there is heavy application of superphosphate.

Q.: We heard this morning Mr Hercus's suggestion that ill-thrift trouble was bacterial. I think there might be scope there for another trial where a lamb apparently infected with ill-thrift is introduced to a fit mob. Do you think it would be a good idea?

Mr Hartley: As I mentioned, we know a little about the causes of hogget ill-thrift, but there is a lot we do not know. The outbreak that occurred on the Hakataramea Station is one that we do not know anything about. Infections are responsible for some forms of ill-thrift, e.g. pneumonia, that occur in some districts, but I think they may be secondary to some primary, and yet unknown, factor. We may find out something about these forms by putting sick animals with healthy ones. We are a little far away from the Hakataramea Station or else we would have done more for them.

Q.: Is it not possible that selenium could be acting as an agent for reducing bacterial or virus infection?

Mr Hartley: At the moment it is not known. I would think that most of the evidence points to the fact that the responses are very much more likely to be due to the fact that it is necessary for normal growth and health, is deficient, and that the responses are due to the remedying of the deficiency. It is not particularly clear as yet and a lot of work will have to be done on the analysis of pasture material to establish quite clearly what the intake is likely to be and what effects other elements have.

Q.: Why was Mr Hercus not given more help?

Mr Hercus: We farmers are ourselves a lot to blame in this respect. We do not like to advertise our problems but to face them on our own. We feel it is a hurt to our professional pride, but it was obvious to me that the position was getting serious, even though my losses were not as severe as some farmers' were. My sole intention was to bring it to the public eye so that attention would have to be given to the problem that confronted us.

Q.: What is Mr Morris's future policy?

Mr Morris: I am dosing the ewes each month with selenium and I am sure that they will retain enough selenium to produce thrifty lambs.

Q.: Does the College propose to repeat the trial at Ashley Dene with the topdressing of minerals in view of the fact that there was a severe drought last season?

Dr McLean: At the moment we do not propose to continue with that particular trial. We have reserved the area for other trials which we regard, in the light of evidence put forward, as having a higher priority.
Q.: Do Mr Morris and Mr Hercus run cattle with their stock, and if so, in what quantity? Do they think it has helped?

Mr Hercus: Last season during the height of the outbreak we had cattle and sheep running together. There was no difference whatsoever.

Mr Morris: In my case, I am afraid that is one of the few things I have not tried.

Q.: Has anyone experienced similar trouble with cattle?

Mr Hartley: In some parts of the North Island farmers have quite a lot of difficulty carrying their heifers during the winter. In Rotorua we have had a definite growth-rate response to selenium, but the heifers that we have been treating were not unthrifty.
CUTTING COSTS IN FARMING
ESTABLISHMENT AND MANAGEMENT OF
PASTURES

G. A. Holmes, Invermay Research Station, Mosgiel.

One of primitive man's greatest triumphs, the domestication of animals was not followed by any studied attempt over the centuries to improve pastures for ruminants. For the flocks and herds of nomadic tribesmen there was plenty of natural grazing, mainly xerophytic species, on land unsuitable for cereal cropping. As population increased and tools improved inroads were made into forested land, but even in the reign of Elizabeth I there were still some Counties in England with more than 75 per cent of their land under forest.

The Industrial Revolution, that great period of change in British History, led to an over-rapid increase in population with pressure on the available cultivated land. Most of the famous improvers of British agriculture in the 18th and early 19th century were more interested in arable farming than in grass. They specialised in better ploughs, mechanical grain drills, improved rotations and newly introduced crops—turnips, the Swedish turnip, Italian ryegrass (from Southern Germany) and red clover. Some were notable breeders of improved sheep and cattle.

Grass was regarded as the cost-free cover for unploughable land, and cropped-out arable land could be "rested" by being allowed to "fall down" to grass. This was also the haven of refuge for the farmer when corn prices fell to unpayable levels. Normally nothing was spent on grassland, although with cheap labour it was considered good practice to spread well-made and well-rotted farmyard manure over fields for hay in those wetter districts where the arable land (which had first call on the manure) was less in proportion to the grass. In some places chalk or marl was carted by drays, tipped in heaps before the winter and spread by shovels after the frost had broken it down.

Developments such as the manufacture of superphosphate, the deep mining of potash salts, the fixation of atmospheric nitrogen, the invention of crushers to grind limestone finely, and of machines to harvest and dress herbage seeds have all contributed to our present stage of grassland farming. The oldest of these began less than 120 years ago. Also we have entered into the fruits of the labours of two generations of plant breeders.

Modern grassland farming is a form of "high" farming; that is to say, it demands considerable expenditure per acre to give high per-acre returns. There is an old saying, "High farming is no remedy for low prices," and our anxiety today arises from the vulnerability of our farming to a fall in export prices.

In Britain even in the early years of World War II there were still substantial acreages of old permanent pasture producing as little as it was physically possible for fertile land to do under the rainfall and temperature of the British Isles. A great deal of attention was paid during the war to this weakness in the farming economy. A favourite piece of advice frequently quoted was that the farmer must "treat his grass as a crop." This is probably just as good advice today and at this far corner of the Commonwealth. Although we pride ourselves on our progressive techniques, and have enjoyed a high standard of farm income, there are not a few properties where the grassland has been merely "ranched." Their seeming prosperity

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has arisen from inflation of the currency and a world scarcity of livestock products. To treat grass as a crop means to plan not for months but for years ahead, and to remember not alone the virtues of grass but its failings which necessitate provision of supplementary forage crops (or suitable alternative) and periodical renewal. There is a need for a return to the sound practices of rotational farming which this College has taught and which many of our farmers have demonstrated so successfully.

The grass crop must have proper seed-bed preparation. It must be sown at the best time of year for the district. It must receive plant nutrients appropriate to the soil and climate. It must be utilised at the correct stage. It must be “spelled” to enable it to recover.

**Cultivation**

Cultivation is one of the most costly items in the farmers’ budget, and it is difficult to foresee a sequence of events which would bring about a reduction in wages, fuel costs, or repair bills. If I might throw out an idea to the College on the subject of tractor costs, it would be to initiate trials covering costs per acre worked by different makes and sizes of tractor. You will all appreciate the difficulties and pitfalls in a project of this sort. One would expect to find that the largest acreage for each £1 spent was achieved by the larger diesel and semi-diesel tractors when pulling implements of a size to match their draw-bar horse-power. In any circumstances it is false economy to skimp cultivation work in preparation for grass; the seed-bed must be clean, fine and very firm.

**Cover Crop**

The inclusion of a cover crop with new grass can prove false economy if it is unduly competitive with the young grass for sunlight or soil moisture or plant food, or if it cannot be grazed when the young pasture requires grazing. On good fertile soils even 3 lb per acre of rape can detrimentally affect establishment of the clovers and slower-establishing grasses. On second-class soils up to 1 lb of rape can be included without much harm because it does not grow too vigorously. Short-rotation ryegrass and perennial, too, can be just as damaging as any cover crop on the establishment of timothy, cocksfoot and clovers.

**Seed Mixtures**

Some really worthwhile economies can be suggested in designing the seeds mixture. It is very wasteful to include expensive seeds such as timothy and cocksfoot, and then to “drown them out” with a bushel and a half of ryegrass.

At Invermay over the past four years Mr N. A. Cullen has been working on problems of pasture establishment, and has shown by tiller counts and point analyses that the use of high-seeding rates of ryegrass can result in severe suppression of slower-establishing species, particularly cocksfoot, timothy and white clover. Red clover is less sensitive to competition and is not affected to the same degree. With lighter rates of ryegrass this competition is less intense, and as a result sward composition is likely to be superior, while production, except for the initial phase, is comparable.

In the South Island generally there appears to be a swing away from ryegrass, but figures are still lacking to show the relative seasonal production of special-purpose pastures based on timothy and/or cocksfoot. Further, very little has been done as yet to study the growth rate of lambs on pastures of varying but known composition. The increasing use of timothy on the more fertile soils dates
from the introduction of bred, leafy strains which are immeasurably more productive than the commercial timothy imported in pre-war years. Experience shows that in many districts lambs do better on timothy-dominant pastures, but exact data with any reasons for this have not yet been worked out. If we are going to adopt timothy more widely there are several major questions calling for solution, e.g., rate of seeding, method of sowing and particularly the use of a compatible bottom grass other than ryegrass.

A straight-out reduction in the pounds of ryegrass per acre can be a useful saving, but so can improved methods of sowing. Provided the seed-bed is really good, a set of Blackmore coulters can pay for themselves in the saving of seed on one decent-sized paddock. The use of the roller drill has also proved a good system for economy both of seed and of tractor hours.

Fertilisers for Pastures

In the next paper Mr Lobb will be dealing in some detail with the subject of fertilisers, and here it may be sufficient to touch briefly on some possible economies which may be applicable on certain farms in certain districts. Broadly speaking it may be safe to say that the run-out pastures one sees from any road are those which have not been maintained by judicious topdressing. However, there is a considerable field of work to establish the optimum payable amount of lime, fertiliser and minor element (if any) for soils from the lightest and driest to the heaviest and wettest.

These applications form a good illustration of the law of increasing returns moving at a point to the law of diminishing returns. Because lime has been cheap (having increased over the past 25 years by a less percentage than anything else we buy), and because we can get it spread by ringing up the bulk sower, there may have been some over-use of lime on certain farms, but there are millions of acres which have received insufficient lime. On soils which show a molybdenum response (but which contain molybdenum in an unavailable form) it is much cheaper to use molybdenum than to release it in the soil by heavy liming.

The very success of molybdenum as a key to pasture improvement and of cobalt for lamb thrift has led to a great spate of application of minor elements. Hundreds of thousands of pounds have been wasted in the past few years by applying trace elements without any real proof of their value on the particular soil. Some of the recommendations being made by itinerant salesmen are just sheer nonsense.

Management

It is impossible in our unpredictable South Island seasons to follow counsels of perfection in grazing management. A dry spell sets in; no one can foretell whether it will last a few weeks or a few months or a whole year. Our pastures do give considerable elasticity in seasons worse than average, and they do have amazing powers of recuperation after over-grazing. One serious weakness is failure of many farmers to hold reasonable reserves of hay which in the season just over would have prevented part of the heavy losses suffered almost throughout the South Island.

Good grazing management is largely dependent on adequate subdivisional fencing, but this is costly and there are no signs of a reduction in the cost of fencing materials. The electric fence, of course, is very much cheaper than the seven-wire orthodox fence.

Pest and Weed Control

In the years preceding World War I, pastures mostly ran out to weed grasses and flat weeds, not much palatable feed for grass grub,
Porina, or stem weevil. Because we grow better pastures, and perhaps for other reasons which we do not know of, these pests have become apparently much more widespread and more serious. We must use an insecticide and we are fortunate that one so effective has been discovered. We must spray at times for certain weeds and continue our research to find spray materials effective against docks, barley grass, sweet briar and others which offer special difficulty.

The reason for our consideration of cost economy is the present recession in some commodity prices. We could take the pessimist’s view that the policy should be to “run for shelter” to a grassland ranching system, and to spend nothing on the land at all. The trouble then would be that our inelastic and irreducible overheads would swallow up an undue proportion of our returns.

I prefer to think that optimism will prevail, that run-out pastures will be ploughed with a planned integration of diversified cropping, and that waste of time and waste of money and waste of land will be more rarely seen.
SOME RESULTS OF FERTILISER TRIALS AND THEIR IMPLICATION ON THE MORE EFFICIENT USE OF FERTILISERS

W. R. Lobb, Department of Agriculture, Christchurch.

Perhaps the most striking and important facet of agricultural practice is the change wrought upon it by the use of fertilisers. It may appear strange that recommendations for the use of these are not yet complete, and that each year sees some notable advance in our knowledge of how to apply them.

In this paper I will be quoting freely from trials which are the work of many officers of the Department of Agriculture, and I wish to acknowledge that fact. Much of the working knowledge of day-to-day use of fertilisers has been arrived at by empirical means and established by general practice. Some of the points raised here I hope will indicate to you the need to replace this with factual data, and the experiments so freely referred to are a continuation of efforts to obtain that information. It represents the work of numerous instructors from Otago to Nelson.

It is impossible for me to give specific information to any of you and I must make the point that anyone who wishes to discuss his own problem, should do so with his local instructor. I will simply outline some of the experimental results obtained with phosphate, sulphur, molybdenum, nitrogen and lime, as they may affect the broad practice of fertiliser usage.

Sulphur

Although sulphur deficiencies were shown to exist in the 1920's, it was left to workers in the present decade to re-discover and establish the extent and importance of this deficiency. At this stage there is still a lot to be investigated as regards sulphur deficiency in the South Island.

Certain plants show certain symptoms of this deficiency; for instance, rape leaves affected by sulphur deficiency show inter-veinal chlorosis with no marked mal-formation, but with the pale yellow areas occurring between the veins. There is no doubt that this deficiency is widespread and it almost certainly covers an area of 10 to 12 million acres in the South Island. When its importance was first established I am sure no one imagined that this would be shown to be one of the most extensive deficiencies occurring on such a wide range of soils throughout the South Island. It does not appear to be confined to any soil type or region. There have been a number of speculations as to the situation under which sulphur deficiency occurs, but it is apparent now that it occurs on the heavy coastal soils, such as those in North Otago so frequently used for cropping and market garden production.

It also occurs on the light stony soils on the coastal areas of North Otago, South and Mid-Canterbury and in Marlborough. It occurs on these stony soils in inland situations wherever they are found in Canterbury. It occurs on the inland terraces, hills and downs of Canterbury, North and Central Otago and in Marlborough. It is common to areas with rainfalls under 20 inches, and it has very important implications on how these areas should be farmed. I will refer to these later when dealing with sulphur in connection with an arable cropping system. It is important where rainfalls are over 60 inches and this is the case of many of the inland East Coast areas subjected to the N.W. shower. It occurs on acid soils with pH below 5 and over that vast area of Canterbury where it is about 5.2 to 5.6. Its original
occurrence was demonstrated on the soils of limestone origin, some of which had pH over 7. These limestone soils responsive to sulphur occur throughout North Otago, South and North Canterbury.

It can be seen from this that soils of widely differing origins in widely different situations and with quite dis-similar climates can all be involved with sulphur deficiency. It would seem that one very important factor in this is low organic matter, and this should be remembered as it may have most important implications on the management of these areas, when sulphur deficiency has been corrected. Cropping, for instance, is important on areas where rainfalls and stocking rates are too low to complete the turnover of the organic matter.

It has been shown for instance that cultivation can correct sulphur deficiency on some soils, and this arable system is most important to the low-rainfall areas of North Otago, South, Mid- and North Canterbury. Conversely, where rainfalls are high, full utilisation of fodder by conservation of hay and silage is equally important in the economy of the sulphur turn-round and would be a recommendation for the efficient use of fertilisers on those areas with good grassland climates with rainfalls around 40 inches.

Forms of Sulphur

In discussing sulphur deficiency, it is necessary to consider the forms that may be used. For the purposes of this paper, the forms discussed are coarse and fine elemental sulphur and the sulphate, gypsum. Gypsum, as occurring in superphosphate, is the quickest acting, and the fine form, as in flowers of sulphur, next; the coarse forms vary according to particle size. The forms of sulphur have an important bearing on their use; for instance, with quick-growing crops like rape, the sulphate is necessary to give maximum response, very-fine forms like flowers are partially effective, and the coarse forms not at all. This factor is involved with the quickness with which these forms are available to the plant, as elemental sulphur has to be converted in the soil by sulphur-oxidising organisms before the plant can use it, and this depends on the activity of these bacteria, in the soil. It has been shown, for instance, that for establishing clovers under low rainfall, gypsum may be more effective than sulphur and this is very important in relation to oversowing practices. Conversely, it has been demonstrated that under high rainfall, sulphur may be more effective than gypsum, which may be lost under these conditions by leaching before the plant can use it. With established legumes, any form of sulphur should be effective in correcting sulphur deficiency, but quickness of response will depend on the form used. In practice, it would be necessary therefore to use coarse sulphur somewhat ahead of the time a response would be expected from using gypsum or, of course, superphosphate.

Rates of Application

Rates of application of sulphur will vary, depending on several factors. Trials indicate that maximum responses vary from rates from 10 lb to over 1 cwt in certain cases. In general, for improved conditions, rates between 10 and 40 lb may be sufficient. In marginal areas rates between 20 and 30 lb seems to give increases in production to a level where utilisation of the increased production may become the factor which restricts the use of any greater amount. In efficiently using sulphur, therefore, especially in the improvement of low-production areas, it is necessary to know how effectively the production obtained can be utilised before a decision on the kind and the amount of sulphur to be applied can be given.
Frequencies of Application

Frequencies of application are being studied in a number of trials, and it is obvious that this will be a variable factor, depending on rainfall and management. It has been shown on a moderately-free-draining soil with a moderate rainfall that 1½ cwt of super (or the equivalent of ½ cwt gypsum) was effective for only a year. In many cases, where the effects from superphosphate have been due solely to the sulphur it contains, it has been possible to arrive at an empirical assumption of the residual effects of sulphur applications made in the form of gypsum. You know that these vary to some extent, but with the moderate applications made throughout this area, in general a decline in production is fairly rapid once topdressing of an area is withheld. As I have stated before, this decline is influenced largely, however, by the stocking rates and utilisation of materials produced. In the case of sulphur, however, residual effects may be longer, and this is one reason why sulphur may be a more economic material to correct sulphur deficiency than gypsum.

Some trials that have been in progress for periods of up to four years, have shown no great decline in the responses from sulphur applications at rates of 20 to 30 lb per acre.

A trial in Mid-Canterbury is showing some interesting responses in relation to previous gypsum usage. This is on a Lismore soil, originally deficient in phosphate, molybdenum, sulphur, and possibly lime. After years of heavy liming and use of superphosphate, the soil has been built up to high production and has a pH of over 7. After discontinuing the use of fertiliser on this area for two years, sulphur responses became of major significance, and in the third year approximated a 50 per cent increase in yield of dry matter produced per acre.

Phosphorus Deficiency

The next most important deficiency is phosphorus, and this of course has received most attention on New Zealand soils. This deficiency occurs over a wide area and is possibly more widespread than sulphur deficiency. It occurs on most soils where sulphur deficiency has been shown and in addition occurs on many soils in the Marlborough Sounds and in Nelson, on the West Coast and on Banks Peninsula. It occurs also on many of the heavy soils of the Canterbury Plains, and no doubt in many areas in Otago and Southland where sulphur deficiencies have not been shown.

Phosphorus on Crops

Phosphorus is an acute deficiency on many crops, especially the brassicae, and throughout the south much of the importance of phosphatic fertilisers has been established empirically through their use on crops. This factor has, I think, led to the establishment of the over-importance of phosphate as a deficiency on South Island soils.

On soils which may be deficient in both sulphur and phosphorus, phosphorus deficiency may assume the more important role in crops, as the deficiency of sulphur may have been partially or wholly corrected by cultivation and the break-down of organic matter.

In discussing the question of fertiliser response by way of super-phosphate, it is necessary, therefore, that we realise that there are soils which respond to sulphur without phosphorus, and those which respond to phosphorus without sulphur, and we must also know that crops vary in their response to the fertiliser used. It is possible that on the one soil we could be recommending sulphur only for pasture, phosphorus for some crops (the brassicae) and no fertiliser at all for other crops (wheat).
Fertilisers on Crops

This brings us to the question of the usage of fertiliser on the cereal crops. Over the five-year period 1952-3 to 1956-7, trials by the Department of Agriculture have shown no great response from the use of superphosphate on the wheat crop. In Canterbury there were 43 trials in this project, and the average yield increase was an insignificant 1.3 bushels per acre. This is not so with barley. On 14 trials with barley over three years, 1 cwt of superphosphate has given a yield increase of nine bushels per acre, and in many cases higher increases have resulted from the use of 2 cwt.

Sulphur on Crops

A check has been made on the cereal crops to confirm that the responses to superphosphate are due to phosphorus and not sulphur. In nine trials with wheat, there has been no advantage with superphosphate over double super and the same is true of ten trials with barley, where the average increase has been a non-significant 1.1 bushels per acre.

Nitrogen on Crops

In 60 trials with wheat over six years, a small increase of 1.8 bushels resulted from the use of nitrogen, but this would not be an economic way to use it, and trials indicate that this state of affairs is true of cropping in general. It would seem, therefore, that neither sulphur nor nitrogen are important fertilisers in cereal cropping. This state of affairs could be expected in an efficient (and I mean efficient) grassland-cum-arable system, but may not be expected to hold good under continuous cropping or cropping on a poor system of grassland utilisation. The reason for this is to be found in the return of both nitrogen and sulphur through the animal and breakdown of organic matter. The place of nitrogen in South Island farming would be confined to some crops of small seeds, and in some instances, for autumn-saved grass.

I must again emphasise that I wish no one to accept any remarks made here as a generalisation of the fertiliser practice to adopt. This is a matter for the local instructor to advise. For instance, I may have left the subject of pasture topdressing with the impression that sulphur may be more important than phosphorus. For some areas, this is not so. For instance, it is being found that on some of the Motukarara sandy and silt soils, pasture requirements for phosphorus are very high. These soils in general are high phosphate testing soils on which phosphorus occurs in a form unavailable to the plant. In such a case, an application of 4 cwt of super may be necessary, and it may also be necessary to repeat this dressing at fairly regular and short intervals. In these cases phosphate responses are generally observed both on the clover and the grass itself.

Molybdenum Deficiency

The next deficiency of note is molybdenum, and the importance of this deficiency on the marginal soils of the South Island has not been fully appreciated, except for a few areas where spectacular results followed its use in the early 1950's. Recently this deficiency has been established on many of the marginal soils of Canterbury, on the gravelly soils of the plains and on the clay downs. Evidence now shows that this deficiency is widespread, occurring on soils in Southland, South Otago, Otago, North Otago, South Canterbury, Mid-Canterbury, North Canterbury and Marlborough. It is a critical deficiency of some areas of the Marlborough Sounds, of Banks Peninsula, of the Moutere gravels and other soils in the Nelson Province.
This is a true micro-element, and very small amounts are needed. The usual rates of application are between one and five ounces per acre, and once again you should consult your local office for advice, because excessive uptake of molybdenum by the animal can upset copper metabolism.

Molybdenum deficiency causes certain symptoms in plants—a pale yellowing in clover leaves and a marked stunting of growth. This yellow colour shows in all crops affected. It causes marked distortion of the leaf tissues of crops like cauliflower, rape, and turnips and a marked stunting as well. This symptom could be confused with manganese toxicity, and symptoms should be used as a diagnostic tool only after confirmatory information from experiments is available.

Molybdenum affects all crops, and responses on turnips, rape, wheat, oats, barley and peas have all been of considerable significance. Molybdenum is cheap to apply, it can be sown with the seed, as a dust, it can be sprayed, or it can be used with the fertiliser, and it can be effectively used at any time of the year. At the risk of being a fanatic on this matter, I am convinced that there is still a large area of molybdenum-deficient country on which it would be payable to use this material to achieve greatly reduced costs of fertiliser efficiency.

Multiple Deficiencies

As I have mentioned sulphur, phosphorus and molybdenum, it may appear I am dealing with these as separate problems. Although there are areas—quite extensive in the case of phosphorus and sulphur, and less so but none-the-less significant in the case of molybdenum—where they occur as single deficiencies, by far the greater areas are those where they occur in combination. Where this is so, all deficiencies must be corrected. In general, the most common triple deficiency is that of phosphorus, sulphur and molybdenum, and it is fortunate that all three can be corrected by the use of molybdic superphosphate.

The common dual deficiency is that of phosphorus and sulphur, and in the past, superphosphate has corrected this situation, but the part played by sulphur has not been fully realised.

Ratio of Sulphur to Phosphorus

Now that this situation has been investigated, it is possible that for a number of areas it would be more economic to have a higher proportion of sulphur in fertilisers for use on many of these areas. The ratio of sulphur to phosphorus in super is 1.3 : 1, whereas the ratio of the sulphur to phosphorus in organic matter is 2 : 1 and is fairly constant. Thus, if all the sulphur in super were used to build organic matter then only two-thirds of the phosphorus could be so utilised, if the ratio in organic matter were to be maintained. This would suggest that a higher rate of sulphur may be beneficial in most, if not all, cases where the two deficiencies occur together. Fertilisers to which sulphur have been added are now being made. The tables in the text of this paper set out how the proportion of phosphorus to sulphur and how the form of sulphur varies in these mixtures, and a further table shows how these can affect the cost of applying 30 lb of sulphur per acre. In approximate figures, this varies from 24/- per acre for super only to 6/8 per acre for sulphur only. With the usual mixture of 400 lb of sulphur to the ton, the cost is 13/2, or about half the cost of super.
TABLE 1

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<tr>
<th></th>
<th>P as Gypsum</th>
<th>S as element</th>
<th>S Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Super</td>
<td>10</td>
<td>12.5</td>
<td>12.5</td>
</tr>
<tr>
<td>Super/240.S</td>
<td>9</td>
<td>11.2</td>
<td>23.2</td>
</tr>
<tr>
<td>Super/400.S</td>
<td>8.2</td>
<td>10.2</td>
<td>30.2</td>
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<tr>
<td>Super/800.S</td>
<td>6.4</td>
<td>8</td>
<td>48</td>
</tr>
<tr>
<td>Sulphur</td>
<td></td>
<td>112</td>
<td>112</td>
</tr>
</tbody>
</table>

By using this information, some landholders on areas highly deficient in sulphur have increased the amount of sulphur to the allowable limit for air distribution, that is two-thirds of a filler (generally super) to one of sulphur. This mixture is then applied at the rate of ½ cwt per acre or less, making considerable economies in the topdressing of many marginal areas. Such a mixture has been applied for 9/- an acre.

I would like you to observe also that in using mixtures of sulphur and super you are applying sulphur in two separate forms, as the element and as the sulphate. By so doing, you would be getting some protection from the factors already mentioned where variable rainfall could influence the results obtained in oversowings between the usefulness of either gypsum or sulphur.

Lime

Lime has been used to improve many areas of the South Island, and Southland may owe its position in farming today to it. From Southland to Canterbury came many farmers seeking an easier life and sunshine, and with them came lime. Many areas of South, Mid- and North Canterbury, both the stony soils, and the clay downs were subjected to heavy liming for their improvement.

Lime has many beneficial effects. It can assist nodulation, it can release molybdenum and it can suppress excesses such as manganese, iron and aluminium. It makes the soil less acid and thus assists to support a free-living population of bacteria, micro-organisms and earthworms, which can be of the utmost importance. It should be remembered that correcting molybdenum deficiency by adding molybdenum is therefore not the same, nor generally as efficient as correcting it by adding lime.

It is almost certain that more lime than is necessary has been used in the improvement of many areas. It is almost equally certain that one reason for this was that lime has been correcting molybdenum deficiencies on many of these soils. This was true, I think, of areas in Otago, North Otago, South, Mid- and North Canterbury and in Marlborough and Nelson.

Investigation of Fertiliser Requirements

With the knowledge that many areas have been improved without a full understanding of the effects of the fertilisers used upon
them, it has become necessary to re-examine the situation. This presents several problems, and an approach to this necessitates that the investigation be made on unimproved areas of the same soils. Recently this has been done in a series of trials of the Lismore stony soils of Canterbury, and of a series of 18 experiments, 15 responses to molybdenum were recorded. On the other three trials, no establishment of legumes took place, and consequently no responses were recorded. Although it was known that these soils could be molybdenum deficient, I don't think it was expected that such an extensive area of them would indicate molybdenum deficiency to this degree in their unimproved state.

However, the responses on these soils are multiple ones and involve many factors in which molybdenum, sulphur, phosphorus and lime—and in some cases, inoculation—might all be important. This was shown also in the series quoted, where sulphur responded on all the unimproved sites, as also did phosphorus. In general, lime responses were recorded on most, and lime together with molybdenum were generally better than either alone. It is possible that the major effect of lime in this series of experiments was in obtaining more efficient nodulation of the oversown legumes.

Recent trials are showing that molybdenum is important on much of the clay-downs country in Canterbury as has been established in South and North Otago. Many of these soils too, are being shown to be sulphur deficient in their unimproved state.

This knowledge then should be used to increase the efficiency and the economy of the fertilisers used on them. Traditionally, super applications recommended are about 2 cwt per acre. This would supply 22 lb of sulphur and 20 lb of phosphorus as the elements. The fertiliser which might now be recommended in initial improvements would be one of the so-called "fortified" fertilisers, and that generally used should contain 400 lb of added sulphur to the ton and be applied at 1 cwt per acre. As a direct consequence, this is half the quantity of material to be handled. This latter fertiliser supplies 9 lb of phosphorus, 30 lbs of sulphur, and in most cases it should contain between 2 and 4 ounces of sodium molybdate. For materials then, these two mixtures would cost for 2 cwt super approximately 20/-, and this would be the less efficient one; and for 1 cwt of molybdic sulphur super (the efficient one), 15/-. In some cases, the use of the fortified fertiliser without the inclusion of molybdenum will give completely negative results. The addition of a small amount of molybdenum at a cost of a few pence per acre could mean all the difference between efficiency and non-efficiency.

When comparing these fertilisers, they should be assessed against the effect of lime and super, which has been the traditional method of improvement. If a ton of lime were used, the material handled in this case would amount to 22 cwt, at a cost on many areas of about £3 per acre, and achieving no better result than could be achieved from the expenditure of 15/- per acre on 1 cwt of a molybdic sulphur super.

Deficiencies of Minor Importance

There are some other possible deficiencies, and those being shown to be of minor importance at the moment are managanese and boron. Manganese deficiency is of some importance, as it is known to affect peas with the complaint known as "Marsh Spot" and its occurrence in the wheat crop in both Mid- and North Canterbury has been reported in recent years. Manganese can be rendered less available by the use of lime, and a number of cases where lime has suppressed the effect of super have already been noted.

Boron deficiency and its effect on the root crop is well known,
and this deficiency has been made more extensive by liming. Recently boron deficiency has been shown to be of some importance on the lucerne crop in a number of areas, notably Central Otago and Nelson. In Nelson, it has been shown to be a limiting factor for clover and hence for pasture production, especially following improvement by the use of lime and super.

It is necessary to state here that a number of other deficiencies are continuously under study throughout practically all areas of the South Island, and I should mention potash in this respect. Potash has been shown to be of some importance in the higher-rainfall areas of the West Coast, Nelson, South Otago and Southland. On the East Coast throughout the lower-rainfall strip from Otago to Marlborough, however, potash, although used in numerous trials, has been shown to be of little importance, and in fact some definite suppressions from its use have been noted. Whether this position will remain it is not possible to answer, but nevertheless should a deficiency occur, it would be no doubt picked up under the present experimental programmes.

**Inoculation**

On the more difficult marginal areas, nodulation of the legumes is a problem and I mention it here only because if this should be so, you will get no worthwhile result from the use of fertilisers until you achieve efficient nodulation of the clover plant. Lime has an important bearing on clover nodulation and this no doubt has been one of its chief attributes in some areas. It was once thought that clovers had to have sweet soil and that they would not thrive on acid soils. This might not be so, and low rates of lime on soils with low pH may be effective in obtaining nodulation and achieving vigorous, healthy, clover growth. Frequently, one sees vigorous clover occurring on trial sites where the pH is below 5.

I would like now to do some speculating on the question of fertiliser use as I see it.

In the first place there must be a few exceptions to the rule. For instance, there are some soils (possibly in many districts) where trials with fertilisers on pasture have given no responses whatever. The best known of these are the Waimakariri series. Many of these soils are kept in a relatively-short rotation of crops and pastures. In crops of the barley type, however, these may respond to phosphates. By far the greater area of soils, however, have depended for their improvement on the use of minerals like molybdenum and phosphorus and minerals or organic substances like sulphur and nitrogen to stimulate clover, crop and pasture growth to increase their fertility.

In general, in times of economic stress fertilisers are withheld from these soils and in general too, they are withheld in an inverse ratio to their usage in times of plenty. In other words, those farmers who have used fertilisers most and recognised their importance in building soil fertility on their farms are the most reluctant to reduce their use, whereas those farmers of lesser efficiency, see an easy way to reduce costs by reducing fertiliser input. In point of fact both these policies could be wrong. I would suggest, however, that more recent knowledge of what deficiencies are being considered could be used to assist with advice on what may be reasonable fertiliser practices to adopt, both within the cash crop-pasture system and for the fodder crop-pasture system.

The steps to be considered in framing this advice would be:

(a) To know or find out what were the original deficiencies of the soils concerned.

(b) To investigate the degree to which these have been corrected.

(c) To recognise the influence of climate, management, type of cropping on the organic and mineral deficiencies. This, for example,
includes knowing the effect of lime on the numerous factors mentioned earlier.

(d) To formulate a system of fertiliser use for production of pastures and crops which will make the greatest use of all the fertilisers applied.

It would seem with regard to the above points that some definite changes in our ideas are likely. As examples, I would suggest at the one extreme the marginal lands where nothing is likely to be achieved until the factors which limit nitrogen fixation by the legume plant are found, and corrected. When this is done, some marked improvements are likely, and many of these areas may be as productive as, or even more than, many of the areas already developed.

At the other extreme, I would take as an example that vast area of yellow grey earths which may have been deficient in molybdenum and sulphur before they were improved through the agencies of lime and superphosphate. It may be that it will be possible to recommend a system wherein phosphate deficiency is corrected during the growing of certain crops in the rotation, the brassicae, and that emphasis on pasture will be based on pest control and the use of sulphur. Some crops under the ideal system will be grown without fertiliser, neither phosphorus, sulphur nor nitrogen will be necessary. This is being done with the wheat crop in many areas today. Pasture topdressing trials on this land, hitherto known to be phosphorus deficient now indicate that during their early life they don't respond to any fertiliser, but that sulphur responses will develop later.

Trials in North Otago, at Waimate, Timaru and Ashburton all support this. I think farmers should realise too that pasture management and utilisation, in themselves important, are likely to influence certain deficiencies, especially the organic ones of nitrogen and sulphur.

The system of fertiliser use now being adopted in some areas illustrates this point. On sulphur-deficient, cropping soils in North Otago for instance, one would recommend a rotation of crops and fertilisers like this. From old pasture to rape, which would be supered to supply gypsum (or gypsum itself would be used—note this is a quick acting form for a quick growing crop). Then wheat would follow without fertiliser, then perhaps another cereal, then greenfeed and back to grass. This would be topdressed in the first autumn or winter with DDT super and then topdressed the following year with sulphur or sulphur super. When it became impossible to support high production on this pasture due to dry conditions, it would follow this sequence again. This sort of rotation of crop and fertiliser will, I think, develop in many of the arable areas of the south, taking into account the original soil deficiencies, the build up of these, the organic cycle and the needs of both the crops and the pasture for individual nutrients and for pest control.

How often does one still hear stated: "Use two or three tons of lime on this soil," or "Your fertiliser practice should be a ton of lime at sowing down, 1 ton every four years and 1 to 1½ cwt super every year." This seems to have become a panacea for all areas, irrespective of whether they are now known to be, or to have been, deficient on molybdenum and sulphur. No notice is taken of what the capacities of the soil for lime, phosphorus, sulphur and other individual nutrients might be; no notice is taken of how crops utilise the fertiliser on these soils; little or no attention is paid to how climate and pasture utilisation alter basic requirements of fertiliser. It would be wonderful to think the question could be answered as simply as this, but I am afraid all the facts point against it; with the factors now known, generalisations simply cannot be made.

In concluding I must again stress that I am unable to answer your individual problem and you must consult your local instructor.
for advice on this. I know it is dangerous to make generalisations as I have found myself doing in this paper, and I thus wish to qualify the statements by saying they apply to the areas on which the trials were carried out, and that further trials are being conducted to answer many of the points outstanding.
THE USE OF FERTILITY

W. C. Stafford, Timaru.

When I was asked to contribute to a symposium at this Conference on the Efficient Use of Fertilisers, the immediate reaction I expressed was "No." I said "No" because the words "efficient use of" frightened me. They brought back memories of two things. One—the measured plots and accurate weighings of fertilisers and seed per plot, followed later by weighings of grain, fodder, and pasture yields, and the hours of office work; of student's method and probable error, of thirty years ago. And, two—the indiscriminate manner in which fertilisers and lime have been used over the last 15 years.

The words also brought home to me, the fact that I have little or no knowledge, much less "the efficient use of," of the modern trend in fertilisers of the molybdenum, sulphur, and manganese class, even although sulphur was being suggested as a possible fertiliser in New Zealand in the Journal of Agriculture as long ago as 1918. In fact, my ideas of what is a fertiliser, have become so distorted, that I now regard the development, and the use of the modern farm tractor as perhaps the most efficient fertiliser we have seen up to the present time.

When, however, the subject was changed, I revised my decision, especially when I was told that the titles of papers were subject to alterations, suggested by contributors. In extending to me and to others this latitude, I am extremely grateful. I am sure that if the future Committees continue the policy of indicating the broad outlines of these Conferences, compatible with current trends, and events, these gatherings will continue to be the success they have in the past.

So I have chosen as the title of this paper—"The Use of Fertility."

Those who know me well, will of course immediately say that this is only an excuse, for they well know, that I have preached to monotony for some time, that fertility is something which a farmer should create and use in his fields, and on his farm, many times during his lifetime, and not store and hoard it, as a miser does his gold.

The trend over the last 15 years, the happenings over the last two, and the future prospects, are such, however, that to me it is imperative that greater use must be made of fertility. I believe that to keep on raising the fertility, by the present known means, of most of our land, means only cost and trouble to the land holder. I believe that the high fertility that has been built by the triple alliance of farmer, scientist, and favourable economic conditions, should be lowered and more use be made of the knowledge of using fertility, as it is created.

For 35 years the farmers of New Zealand have been increasing the fertility of their land, under the whip of increased production and the spur of favourable economic conditions. Two thoughts have been behind this, to hasten their own independence, and to benefit New Zealand as a whole. By now it is realised that the latter was right, but the former, hopelessly off the target. For, the farmer, by the increased responsibilities, and troubles he has created for himself by raising fertility, is more than ever tied. If he is to meet the increased costs of production loaded on him by the slogan "that all should share in the national cake," and the increased costs of living and dying, he is more than ever dependent on his farm. Fortunately he has also spent too much in other ways than by increasing fertility; ways that at the time the money was spent, and at the present moment appear, and appeared to be, to the farm financiers, extravagance. But these ways of improved flocks, good fences, adequate water-
supply, good yards, barns, woolsheds, and suitable accommodation and conditions for his men and their families, are the things which are necessary in the use of fertility. For many who have adopted this policy the fat years have been too few. But to all those who have made their farms their banks, and in most cases consequently, their overdrafts too high, I would say now is the time to draw out, and stop paying in. Admittedly, this can be done more quickly on arable land but it can be done where cropping is not desired or not possible.

To scientists and politicians such statements must appear downright heresy, since to them, the future of the country is bound up in increased carrying capacity, followed by increased exports, and consequent increased overseas funds. Further, it is a recognised thought in some quarters that the productive capacity of land is as yet nowhere near its peak. All this may be true, but in the initial doing of it, the sole effort and responsibility rests on the shoulders of the farming community. Further, it is also recognised that there is an optimum of production, the movement of which is dictated by cost and wastage under varying conditions.

This was made plain in agriculture in 1909, 50 years ago, when the following findings were published from Rothamsted, England, while the farmers of New Zealand were still busily engaged in exhausting the last of the virgin fertility of the forest, tussock and arable lands of the country.

It begins: "The greater the amount of fertiliser added to the soil, the smaller is the proportion returned in the crop" . . .

"The general rule is that the wastage (chiefly of nitrogen) is greater the higher the fertility of the soil."

It continues: "Thus the intensive farmer becomes wasteful because after his land is in good heart, he continues to add fertilisers at the same rate as he did when he was building up its condition."

"It therefore follows that an account of what he has removed from the soil, yearly by the crops and stock raised on the farm, provides very little guide towards determining the amount of fertilisers which must be brought in.

"Land in good heart will practically recuperate itself without any extraneous manures, but high farming for big crops involves a considerable wastage.

"It is only by experience, by the knowledge of his own land and the market conditions which prevail, that the individual farmer can tell to what degree he can utilise the information as to the feeding of his crops and stock, which is provided by field experiments."

You will see that as long ago as 1909 the agricultural scientists of that period recognised the importance of the farmer's own experience and the influence of market conditions on farming. I feel that these two facts have tended to be forgotten over the last decade. At the present time they cannot be ignored. Today I feel the farmer hangs too much on the opinion of the research worker or agricultural adviser. I have memories of 30 years ago when a farmer was more impressed with my ability to drive a six-horse team, than ever he was by the fact that I had a Diploma in Agriculture. The annoying fact to me, today, is that his impressions were probably right.

There are many now who will disagree with the findings from Rothamsted of so long ago but to me the principle is still right.

A recent example is that prior to 1934, five bushels increase in the yield of wheat could be expected from the sowing of one hundred-weight of superphosphate with the seed. Today, with land in a better state of fertility, just over one bushel can be expected.

At the present time where mixed farming is practised, under a rotation of cereals, fodder crops, and pasture, and where the land has been well looked after, phosphate is only necessary with the
crops of the rotation, the grazing animals supplying all the necessary fertility throughout the period in grass, except perhaps, for the addition of lime at the time of sowing the pasture.

Further, it is also now recognised that a crop of wheat, even using the high-yielding hybrids, does not much affect land under condition of good fertility. In fact, there is a rising school of thought that over-all farming on land that is arable would be better for it.

To me, however, it is the building and use of fertility on the land which is not arable or on arable land where the holder does not wish to crop, which constitutes the problem of today.

I am of the opinion, and I realise that opinions are not facts, that it has now been sufficiently established that the fertility and consequent productive capacity of land by the present known methods have been and can be raised beyond the capacity of the plants or animals at present living upon it.

As proof of this on the plant side I offer the instance of wheat, where, on a rising plane of fertility, Tuscan was succeeded by Cross 7 which has now been succeeded by Aotea and Arawa, on a continuing plane of fertility.

On the animal side, the increasing mortality and lack of vigour in young sheep grazing on improved land, are similar to the symptoms Cross 7 shows under such conditions. In the case of the sheep it is only under extremely favourable economic conditions towards meat and wool that such a situation can be sustained—to say nothing of the peace of mind of the farmer.

The farmer of today on improved land, whether it be arable or pastoral, is faced with one of three options.

(a) To lower the fertility of his land to the capacity of the animals grazing upon it.
(b) To change the strains of the present plants and animals or introduce or revert to other types.
(c) To dope with whatever is the fashion of the moment—the soil, the plants, or the animal—by topdressing the soil, spraying the plant or injecting orally or hypodermically the animal.

At present the farmer, scientist and merchant, are all out cooperating by groping in the dark on the last proposition.

To me the farmer should be concentrating on (a), that is, to lower the fertility to the capacity of the animal, until the answers to (b) and (c) are found by the scientists who, I know, will ultimately do so. Under the urge of a favourable climate towards farming, the maximum production has been the goal, rather than the optimum. With the cooler external and internal economic winds, the optimum is the only course the farmer can take.

I realise that these suggestions will not find favour in many quarters. It can mean a lowering in production, although I believe the fewer losses sustained will more than offset the fewer numbers. It will mean, however, the satisfying of two vital factors so necessary at the moment—lowering the cost to the farmer and easing his peace of mind.

Before fertility can be used it must be controlled. It is the lack of control over the last 15 years that is the cause of our troubles today. The contributing factors have been:

(a) The pouring on of phosphate, without realising the almost unlimited power and growing ability of the improved strains of clovers to absorb phosphate under naturally-favourable soil conditions or those created for them by lime and/or drainage.
(b) The impression created on the farmer by the phosphate, clover, nitrogen, grass and the grazing animal story (which has never been entirely accepted by the rest of the world, particularly in England, but which has served New Zealand so well).
The favourable economic conditions towards the produce of the sheep.

On a rising plane of fertility the combination of these three circumstances has worked advantageously for the whole of the community. Hundreds of thousands of acres have been improved and as much brought in and stocked, resulting in great benefit to all.

The stage, however, has been reached that the fertility level has been raised beyond the ability of the grazing animal to cope with it.

When I was at Lincoln 33 years ago, it was the ambition of many of my contemporaries who had or could get the money, to own a farm which would carry sheep alone on grass alone in sufficient quantity to enable them to obtain a sufficient income by sitting back and watching the wool grow. This is still the thought of the majority of the townfolk. How wrong it is; for the sheep farmers of New Zealand have not been sitting back over this period, neither are they sitting back at the present moment even although they are watching the sheep die rather than the wool grow.

The thousands of acres that have been brought into production from store-sheep and no-sheep country to fattening country, and the increase in sheep numbers and their quality are proof of this, as are the advantageous times in which all of us are living.

It wasn't done without work and it wasn't done without worry of management and finance. The worry has not ceased for, on a still rising plane of fertility, the land that has been so well improved is losing both its fattening qualities and its ability to breed satisfactory replacements.

To me, cropping or mixed farming is much the easier proposition today. This type of farming has been much better catered for by scientific research particularly in mechanisation.

In the South Island it was by the plough that the initial steps were taken in land improvement. I am of the opinion that it should be by the plough (until science finds the answers) that the farmers on this troubled land should find relief.

We should lower fertility by the growing and feeding of supplementary crops, both fattening and holding, whether they be cereal, grass or brassica, and in addition, if possible, the taking of grain crops. Following these, we should sow mixed pastures during the life of which the grazing animals alone are the fertilisers.

At the present moment I have no brief for such things as the use of hormones and sod seeding or the further use of fertilisers.

I am conscious of the fact that I have expressed my feelings rather too freely, but regardless of this I must add a further one.

In view of the present knowledge of land improvement or the lack of it, whichever you like, the fertility of the montane tussock lands should not be raised by the present known means. If the Romney can't stand it, the Merino certainly can't.

Q.: Was not Mr Holmes a little too scathing about the use of dalapon, especially on brown top?

A.: Our experience with dalapon has not been good and at its present price it is a very costly treatment. I know some districts in the North Island have had quite spectacular results but there have also been lots of failures where the result has been a fine crop of thistles. It is difficult for an officer of the Department of Agriculture to advise a farmer if the results are not predictable.

Q.: Mr Holmes mentioned that he did not advise the sowing of rape as a nurse crop with grass because of the difficulty of controlling it. What is his reason for saying this? My experience is that I can control it.
A.: On good soils the rape grows too vigorously. You wait till the rape is "ripe" and the grass gets drawn up and doesn't tiller well. On that class of country I think it is better to fallow and sow alone. On the poorer soils a bit of rape does no harm because it does not grow so vigorously.

Q. Mr Holmes in referring to timothy and cocksfoot mixtures with white clover, said ryegrass wasn't a good bottom grass to sow with them. Would he suggest dogstail as a suitable grass?

A.: I don't know how often farmers say they get better bloom in lambs from a dogstail pasture; with others it's timothy or cocksfoot. It seems to add up to one thing, that there's something wrong with ryegrass. Perhaps Dr Corkill's long-rotation ryegrass may be the answer. It's only an opinion, but I think dogstail with timothy may be the answer.

Mr Stafford: When I first went to South Canterbury 30 years ago the best lambs coming off the mothers were off pastures which were dominantly dogstail.

Q.: In areas where sulphur is deficient, are we to look upon applications of sulphur (with super) as annual ones until the level is brought up to the condition required?

Mr Lobb: This question is somewhat difficult to answer because it does entail certain variable factors I mentioned in regard to rainfall and stock carried on sulphur-deficient country. The availability of sulphur as such is relatively slow, so you can actually, under very low rainfall, put on fairly large amounts which will last a long time. Applications of say 14 pounds per acre may last for four years or more. On the other hand, where lower rates are used and the rainfall is high, there is a definite decline through the years. With gypsum, loss by leaching is very much quicker.
DIVERSIFICATION OF FARMING

P. W. Smallfield, Director-General, Department of Agriculture

When I was a student here at Lincoln College over 40 years ago there was a current popular textbook on agriculture which defined farming as the business of raising marketable products from the land—the products being crops, livestock or the products of livestock. The text after this definition then went on to state that the maintenance or improvement of soil fertility was essential and that mixed farming—the combination of crop and livestock production—was the surest method of maintaining fertility. Whilst stressing this point it also made it plain that emphasis on individual products must be governed by demand. If crops could not be sold as crops, then attention should be given to marketing them through animals and data on the conversion of coarse fodders and grains into meat and milk were given in tables at the end. In short, the advice was to grow what the soil could be made to produce economically, maintain fertility, and market what was wanted.

All this seemed to me then mere emphasis of the self-evident and was accepted in the same way as my earlier copy book maxims of—"A stitch in time saves nine", and "Many hands make light work". Yet this definition of the basis of sound farming is important; for our discussion here today on diversification really stems from the fact that demand and economy in many countries are not now the deciding influences on supply in domestic farming. Agricultural protectionism and subsidised farming in many countries have drifted into the stage where farmers are paid to produce what they want to produce and not the products demanded, or at least produce at too high a price for demand to be effective in clearing supplies. Hence the anomaly of surpluses and dumping on the one hand, and restricted trade and protected markets on the other. It is against this background that we must consider the future pattern of our farming.

Consider the steps leading up to the adoption of present trade practices of industrial countries. In Europe, protection of agriculture grew up to conserve farming (largely peasant farming) against the competition of farming in the Americas, Australia and New Zealand. The United Kingdom alone adhered to a cheap food policy and, as we are all well aware, New Zealand's farm and export development has centred round the demand of the United Kingdom market. Early protection methods were by tariffs and quotas, but the depression in the 1930's and local stimulation of farming required by the war and post-war conditions brought more intensive protection and the introduction of subsidies to give farmers incomes comparable to those of industrial workers. These protective measures have now been adopted more or less by all industrial countries. Once adopted, they tend to become rigid, and demand becomes less important in influencing supply.

Naturally, therefore, we are worried about marketing increasing quantities of our traditional products, particularly with our current difficulties in butter marketing fresh in our minds. Whilst we applaud efforts to free trade in agricultural products, to rationalise subsidisation and disposal of surpluses, we must realise that protection of domestic agriculture will remain the policy of industrial countries for many years to come. However, even a slight mitigation of unfair practices would be of immense benefit to the marketing of our traditional products, and some mitigation will, I think, occur.
We should not believe that all our present difficulties, real and imaginary, are permanent.

We have, therefore, to consider not only whether diversification of production will help to provide outlets for increased production, but also whether diversification is economically possible. We cannot afford to sell our produce at a loss.

We should now, I think, look at New Zealand farming as it is and in what ways it is likely to change in response to changes in demand. We must not delude ourselves that we can do anything but follow sustained demand within the limits imposed by our economy.

May I first repeat some well-known facts about our pastoral economy. We have 43 million acres under occupation, of which 31 million acres are under pasture of various types, and only about one million acres are under annual crops. The grassland consists of 13 1/2 million acres of native grass and 17 1/2 million of sown grass. About eight million acres of the sown grassland consists of surface sown pastures established on the ashes of a forest fire and about ten million acres of land sown after cultivation.

Breeding ewes, beef and dairy cows are used to exploit these grasslands, which support 46 million sheep (of which 31 million are breeding ewes) and 5 1/2 million cattle (of which nearly two million are dairy cows and over one million beef breeding cows and heifers).

Broadly, dairying occupies 3 1/2 million acres of improved land in pastures and crops, meat production under intensive grass farming about 4 1/2 million acres, and the more intensive types of sheep farming about 23 1/2 million acres.

Basically, the topography, soils and climate have set limits on what we can produce in response to market requirements. Of extreme importance are the facts that only about 20 per cent of the land is flat and rolling, whilst 80 per cent is hilly and mountainous; that the natural fertility of the soils is not high; and that land development has been based on the improvement of soil fertility through pastures and fertilisers. There is a fairly rigid pattern of production imposed by pastoral farming, and additional factors make it difficult to adjust production to short-term market demands. We are 12,000 miles away from our main market in the United Kingdom; major changes in livestock production necessitate changes in breeding stock, which can occur only over a period of years; we cannot afford to make major changes to meet short-term market demands. To change or diversify the pattern of our farm production will therefore be no easy matter although there have been many suggestions on how this might be done.

Our best example of diversified farming is Canterbury, arable mixed-farming which produces crops, livestock and the products of livestock in a pattern which is very sensitive to local and overseas demand. In the field of mixed farming there have been suggestions for more cereal and seed production not only in traditional mixed-farming areas but also in the higher-rainfall grass-farming areas. Suggestions for widening the range of marketable crops have also been made and proposals for sugar-beet production revived.

Because of our dependence on grass, most suggestions for diversification have been for a change of emphasis on animal products— for an expansion of beef production on sheep farms and for beef, veal and pig meat on dairy farms, for a complete change from dairying to meat production on suitably-sized farms and for a more flexible approach to varying dairy products in response to short-term market demand.

Most of the advocates of diversification base their arguments on a criticism of the traditional specialization in New Zealand farm-
ing—the “all our eggs in one basket” theory. Most of this criticism arose last year in respect of the dairy industry at the period when both butter and cheese prices were at disastrously low levels. There was also criticism of the specialization on fat-lamb production, with consequent possibility of excess supplies on the United Kingdom market. Since then, there has been a fair measure of recovery in dairy prices, and the demand for beef in the U.S.A. has both directly and indirectly assisted meat prices.

Nevertheless, these improvements, however welcome, may be only temporary, and it is necessary to look at the whole question of diversification fairly carefully because, before advising farmers to take such an important step, it is essential to be sure that one is on sound ground; to be sure that there will be reasonably lucrative markets for the alternative products and that both the farmers’ net returns and the over-all balance of payments position are better than they would otherwise have been.

To begin with, it must be remembered that New Zealand is not like the United Kingdom and most other industrial countries where there is a virtually unlimited market at guaranteed or subsidised prices for almost any commodity the farmer produces. In New Zealand this state of affairs is at present, for all practical purposes, confined to wheat and perhaps apples. Dairy prices are, it is true, guaranteed, but at a level lower than estimated costs of production. Hence the advocate of diversification to any particular product has to be something of a clairvoyant as regards price trends. This is particularly true of products such as beef, where there is inevitably a considerable time lag between the decision to produce and the despatch for sale of a side of beef—time for the market to do all sorts of odd things.

Let us look first at the possibilities with respect to products for which export markets are unlikely to be found on any but a very minor scale. We are at present self-sufficient, in years of normal yields, in all cereals except wheat, in potatoes and onions, in eggs and poultry products, and in fruits and vegetables, except those which, for climatic reasons, cannot be grown here. There may, depending largely on Australian import policy, be some future for deep-frozen vegetables as a useful supplement to export earnings, but the total is not likely to be large. The only two products which can be regarded as possible savers of overseas exchange on any worthwhile scale are wheat and sugar. Wheat imports have in recent years cost up to £6 million, and imports of raw sugar cost about £4½ million per annum.

This last year, farmers responded well to the increased price of wheat, assisted no doubt by a diminished return for other produce and the prospect of higher yields from the new varieties Aotea and Arawa. It is likely that next year there will be a further increase in the acreage. On present yields, some 300,000 acres need to be grown to achieve self-sufficiency. The difficulty is to determine the point at which the loss in export earnings through a reduction in output of meat and wool, and perhaps other potential exports such as peas and small seeds, counter-balances the saving in imports. At that point, the only virtue in growing more wheat is security of supplies.

The position regarding sugar beet is rather different. None is grown at present for extraction of sugar, and there is no doubt that it could be grown satisfactorily; more satisfactorily perhaps in parts of the North Island such as the Bay of Plenty and the Hauraki Plains than in Canterbury. Nevertheless, Canterbury, particularly South Canterbury, would be the logical place to grow sugar beet because farmers in the region possess the necessary equipment for arable
farming. It might, in practice, however, prove difficult to obtain sufficient areas within an economical transport radius of a factory. More important, information from overseas suggests that the cost of establishing a factory to extract 30,000 tons of sugar a year (less than one-third of total requirements) would be of the order of £3 million. In addition, there would be some loss of export earnings from crops and products displaced by sugar beet. It might well be that similar capital expenditure on, say, an iron and steel industry would effect a greater net saving in overseas expenditure.

We are thus driven to the view that, if diversification is to have any real meaning for New Zealand, it must be in terms of shifting resources from one export product to another. This could take one of the following forms:

(a) Diversion of resources in dairying to sheep farming (or vice versa).
(b) Diversion of resources in dairying to beef or veal production.
(c) Diversion of fat-lamb raising to beef production.
(d) Increasing the carrying capacity of sheep farms, but absorption of the increased carrying capacity in the form of beef cattle rather than sheep.

Technical as well as economic factors generally limit the extent of movement between dairying and sheepfarming, but there is some evidence that a considerable movement towards sheepfarming from dairying has taken place, not only in the more conventional sheepfarming districts such as Southland, where dairy cow numbers between 1950 and 1957 dropped from 52,000 to 38,000, but even in traditional dairying areas. For example, in the South Auckland Land District, dairy cow numbers between 1952 and 1957 increased from 691,000 to 767,000 or 11 per cent, in spite of the great expansion in dairying on the newly-developed pumice lands of the Central Plateau. Over the same period, breeding ewes increased from 2.6 million to 3.8 million or 46 per cent. On a national basis dairy cow numbers have been practically static for the past five or six years. It is not unlikely that at present they have dropped because of the high killings of cows last season to meet the demand for boneless beef.

Whether there will be any further move away from dairying because of the lower guaranteed price is difficult to say. Undoubtedly there would be if wool prices were a little better. This type of diversification has, of course, the effect of narrowing rather than broadening the basis of our farm economy.

The second possibility, the diversion of resources from dairying to raising beef or veal is an interesting one. The techniques are well known and the aim is to make fuller use of the breeding potential of dairy cows. Instead of slaughtering the majority of dairy calves for bobby veal, the procedure aims at rearing beef-dairy-cross animals from a portion of the herd as is now being widely practised in the United Kingdom. A certain percentage of the herd, mainly the not-so-good cows, are crossed with a beef-type bull and a percentage of the cows, instead of being milked, rear these calves. One cow can, of course, rear more than one calf (three have been suggested). It has also been envisaged by proponents of the scheme that, after the calves have been reared and weaned, the cows are returned to the herd for the remainder of the season. This may not prove very easy in practice. The scheme has, of course, the dual objective of producing less butter, for which there is not so much demand, and more beef, which is at present in short supply in the world.

The New Zealand Dairy Board's artificial breeding centre at Newstead received applications last year for 12,000 dairy cows to
be inseminated with beef bulls. It is estimated that this will result in between nine and ten thousand beef-type calves. It is interesting to note that most of these applications were from farmers for just a few cows—in some cases two or three—which indicates a very laudable cautionary approach to what is, after all, a very nebulous business.

The proponents of the dairy-beef scheme last year did not, in fact, think in terms of beef at all, but in terms of quitting the calves as vealers. This would certainly fit better into the farm-management pattern of dairying, but there seems to be a general feeling now that the prospects for marketing any quantity of export veal are not particularly good. This means that the calves have to be kept up to the beef stage, and the question is by whom. If the average dairy farmer is to keep them, it can only be by cutting down on his dairy herd, and this would remove any possible profit margin which may exist. Incidentally, it is likely that, if more than 10 per cent of the herd are expected to rear, say, two vealers each, there would need to be some herd reduction in any case, particularly in a dry summer.

The alternative would be for fat-lamb farmers to buy weaned beef-dairy-cross calves in December and January and carry them on for beef production. The matter will be decided by supply and demand, particularly the supply of stores of beef breeds.

This brings us to the third possibility in terms of more beef at the expense of something else, namely, more beef and less lamb. This is a straight out matter of relative returns. As Dr McMeekan has demonstrated at Ruakura, while in terms of meat production per acre, beef compared quite favourably with ewes plus cattle, in terms of relative profitability per acre the tale was a sad one. Admittedly, this comparison was made when wool prices were higher and beef prices lower than they are at present, but even now with wool at 3/- there is still a margin in favour of sheep as far as the individual farmer is concerned.

In the long run the acid test for beef production must be the question of profitability. There is, however, considerable complexity in trying to assess this, particularly on a national basis. An acre of dairying land producing 180 lb of butterfat (fairly typical of average Waikato conditions, will yield in terms of earnings of overseas exchange approximately £30 with butter at 290/- per cwt, and allowance for milk powder, bobby calves, etc. The same acre will produce, say, 250 lb of beef which, at 1/6 lb f.o.b., will yield about £19. In addition, there will be something for the hides and other by-products. The moral is obvious. Of course, if, say, 10 per cent of our butterfat for butter was turned into meat, the consequent reduction in the supplies to the United Kingdom would have some effect on prices over all. This might have been important 12 months ago, but, with butter prices approaching the level at which margarine tends to replace butter, any diminution of butter supplies cannot be regarded as sound policy for the industry.

At the same time, endeavouring to look at this matter broadly and in terms of future prospects, it does appear:

(a) that, because of the increasing tendency in Europe to protect the small farmer, and because of increasing efficiency of dairy farming in Europe, milk production will continue to expand,

(b) that there is likely to be a reasonable demand for beef for some few years ahead because real incomes are increasing in North America and Western Europe and the taste is for beef as a meat,

(c) the future for wool is in at least some measure of doubt and it
does seem that we are expanding fat-lamb production more rapidly than the markets can be developed.

We should therefore endeavour to pay more attention to beef production, but I feel very strongly that this is essentially a matter of increasing overall carrying capacity, and particularly the provision of winter feed on sheep farms for beef cattle.

One problem in beef production is to forecast trends in our grass-farming methods. Up to the present we have improved our hill country (where our beef stock is bred) by oversowing clovers and topdressing. We have increased overall carrying capacity but the ratio of cattle to sheep has not altered greatly. To carry a greater proportion of cattle to sheep raises the problem of winter keep. Hill country does not lend itself to the production of annual crops by conventional methods, but recent work with weed-killing chemicals indicates that it may be possible to grow root and green fodder crops on hill country without cultivation.

Our present knowledge is far from complete, but I feel that eventually suitable methods will be evolved. Weed-killing elements have been used in trial work to destroy pasture turf before seed and fertilizer are oversown. The general weed-killing mixture has been 10 lb of dalapon plus 2 lb of amitrol and seed and fertilizer have been sown a fortnight after application. To date turnips, swedes and chou moellier have been grown successfully in trials, but there have been more failures than successes. Level of soil fertility seems to be the major factor. Hill country that has been topdressed for several years and is dominant clover, browntop and Yorkshire fog appears to be suitable for turnips and swedes.

A great deal more trial and demonstration work is required, but I am quite sure that eventually fodder crops will be produced successfully on hill country by oversowing. This will enable a higher ratio of cattle to sheep to be carried.

In all this discussion on diversification there are many uncertain factors. We are uncertain about demand and supply; we do not know whether trade restrictions on primary products will be eased or increased; but most important of all we cannot forecast exactly the trends in our grass-farming methods. My own opinion is that the aeroplane, weed-killing chemicals and fertilizers will enable us to transform much of our hill country into first-class pasture land and if this eventuates it will profoundly affect our farm-management methods. Our best course is to adhere to low-cost grass-farming methods, make our system as flexible as possible within the limits of grass farming but avoid hasty changes in response to short-term demand.
WHEAT VARIETIES
L. G. Copp, Crop Research Division, Lincoln.

There have been marked changes in the order of importance of individual wheat varieties during the last three years. In 1957, 60 per cent of the milling wheat was Cross 7; in 1958 it was 32 per cent. Figures are not available yet for 1959 but probably it was down to 20 per cent. Arawa was 19 per cent in 1957, 44 per cent in 1958 and probably about 60 per cent last year. Aotea was less than one per cent in 1958 and most of the 1959 crop was saved for seed so that there should be plenty for this season’s sowing. Hilgendorf, with the premium being raised to 2/- per bushel, increased from three per cent in 1957 to 11 per cent in 1958. We do not know the percentage of Hilgendorf wheat in last season’s crop, but we do know that the number of growers of Hilgendorf increased from 238 in 1958 to 524 in 1959, and although more farmers grew wheat last season than the one before, there was a definite increase in the proportion of Hilgendorf.

Now many of you are wheat growers—and many of you have returned the postcards we enclosed in copies of the “Wheat Review.” From these replies we are able to make a prediction—that there will be a further change in the importance of varieties next harvest. We have received postcards from over 700 farmers, in the South Island, who will be growing wheat this year, 81 per cent will sow Aotea, 16 per cent Arawa, only six per cent Cross 7 and five per cent Hilgendorf. On about a fifth of the farms, two or more varieties will be grown. No doubt the replies we have had are biased—they come from the more alert and progressive farmers, like yourselves, who are most likely to be growing Aotea, but it looks as though there will be only one variety in a year or two. What we have succeeded in doing is the raising of the yields per acre by about 25 per cent, which pleases the farmer, and it has become uneconomical, in most districts, to grow Hilgendorf—which does not please the baker. Probably you farmers will not agree with this; but the breeding of Hilgendorf wheat, because of the excellent baking quality of the flour, was a more notable achievement than the production of two high-yielding wheats, Arawa and Aotea. After all these two wheats do not yield very much more than Dreadnought but they can be grown, and yield well, throughout the South Island.

Some of you will still be in doubt as to the relative merits of the two new wheats. So far there have been cards from 129 farmers who grew both varieties on their farms last season. The average yields from these were Aotea 62 bushels, and Arawa 55 bushels. The average yields per acre for all crops of the four main varieties—cards from over 800 farmers were:—Aotea 60; Arawa 55; Cross 7 48; Hilgendorf 41, and the number of growers of each was Aotea 209; Arawa 521; Cross 7 222; Hilgendorf 104. There were some high yields—even though it was a dry season. Thirty crops of Aotea yielded over 80 bushels—the highest was 113 bushels; 28 crops of Arawa yielded over 80 bushels and the highest was 108 bushels. But when you take into account that the total number of crops of Aotea was two-fifths of the total number of crops of Arawa, you may work out that if there had been only 200 crops of Arawa there would not have been more than 14 crops above 80 bushels.

And again, we worked out the difference between Arawa and Hilgendorf from the 50 growers who grew both varieties, on their farms. Strangely enough we found exactly the same figures as for the totals of all crops.

The difference in financial return is easily calculated between 55 bushels at 13/4 nearly £37 (£36/13/4) and 41 bushels at 15/6 nearly 108.
£32 (£31/15/6), but against this there is something else that is very valuable to the farmer. Hilgendorf is early, and is eagerly sought by the miller, and the farmer will probably have his paddocks cleared before there is any difficulty with transport.

This information was obtained from less than one-sixth of the farmers who grew wheat last season, but it is valuable as it gives some indication of the yields of each variety. If any of you have not sent back your postcard we would be grateful if you would do so now.

I feel sure that you will be more interested, today, in what we are going to do—or attempt to do—than what we have done. First, we are concerned at the implications of having only one major variety. You will remember that in 1952 the majority of the autumn-sown crops of Cross 7 were affected by disease and the yields were low; but other varieties were not badly affected. A similar trouble could affect Aotea. The breeding of an alternative variety will not be easy. One of the disadvantages of increasing the yields per acre is the raising of the yield standard by which future wheats will be measured.

We have made many more crosses between high-yielding wheats bred recently in Europe and high-quality wheats from North America with our own wheats which are already adapted to New Zealand conditions, and possibly one of these crosses will produce a wheat which could be used as an alternative to Aotea—and again it is possible that a wheat with a better baking quality will be developed.

Another approach will be to work on factors which limit yield—diseases and insect pests. We are not entirely satisfied with Aotea by any means. We know that it is more resistant than Cross 7 to leaf diseases—mildew and septoria for example; we know that it is more resistant to footrot; but it is not immune. You have heard about cereal-yellow-dwarf virus. Some of you have seen the effects of it in your crops of Aotea. The blackening of the ears is caused by a fungus which attacks plants previously infected by the virus. Some farmers were very concerned about this last season, but we did not hear very much about it after the harvest, when many of the infected crops yielded about 60 to 70 bushels. Aotea and Arawa are more resistant to this disease than Cross 7; but we consider that the cereal-yellow-dwarf virus is probably the most serious disease of our South Island wheat crops and we are working on this problem.

There are many farmers in the North Island who will be growing Aotea; 27 of them have sent back the postcard and there will certainly be others. We have not recommended Aotea for growing in the western parts of the North Island because it is not very resistant to leaf and stem rusts. Last year, however, Gabo, the variety that has been recommended for spring sowing in the North Island, was infected with stem-rust and yields were much lower than were expected. Farmers may get away with the growing of Aotea except in seasons when there is a great deal of stem-rust. Aotea is more resistant to stem-rust than Arawa but is not as resistant as Cross 7. Gabo is highly resistant to leaf-rust and both Aotea and Arawa are susceptible; but in New Zealand this disease is not considered to be as important as stem-rust. One of our projects, well under way, is the production of a strain of Aotea resistant to both stem-rust and leaf-rust, so that Aotea can be grown with confidence in the North Island.

We have been trying for several years to make Aotea immune to mildew, a disease which often alarms farmers though it rarely does any real damage. We did not make any real progress because Aotea is already fairly resistant, and here at Lincoln the test plots were so slightly infected that we were not able to sort out the plants to keep and the ones to reject. We could have carried out this work where mildew is more severe—some parts of the Ashburton county would be suitable places—but we have found an easier way to do the job. We have a variety, a miserable looking wheat itself, which has resistance
to leaf-rust and mildew. The two sorts of resistance stick together, so that we can select plants resistant to mildew or to leaf-rust, according to the infection, and be sure that we have both characters in the plants.

This work of breeding for disease resistance is facilitated by the use of the growth chamber. We are able to grow five generations of wheat plants in one year and make the crosses regardless of the time of year. The growth chamber is maintained at an even temperature of 70 degrees by a battery of fluorescent tubes to provide heat and light, and cooled by the circulation of artesian water through a heat exchanger. The unit has been so successful that we have started to build another one so that we may make a more intensive effort on the problem of the cereal-yellow-dwarf virus.

I realise I have given you a very sketchy account of the work and I know that I have left many gaps. I have, intentionally, used the word “we” throughout because the successful completion of any major work of wheat breeding will depend on the willing co-operation of many colleagues, the plant-disease men, the test bakers, the field officers, and last but not least the farmers who will make land available for the final field trials.

One last point. Those of you who still have not sown your wheat may be wondering about varieties for spring sowing. In our experience, Aotea and Arawa are just as outstanding for yield when spring-sown in Canterbury, as when autumn-sown.
AVOIDABLE HAZARDS IN THE GROWING OF WHEAT

I. D. Blair, Lincoln College

A couple of years ago one of my farmer friends used to say with some force: "You don't think I am going to mess up my land growing low-priced wheat for the Government . . ." There has been a sharp change in attitude and the augmented wheat acreage in the South Island is evidently correlated with the facts of diminished returns from pastoral products. The drought of this 1958-59 summer is also likely to contribute towards an even larger wheat acreage as it has been shown that wheat is a reliable crop under drought conditions. My task as a general practitioner in agriculture is to help farmers cut their losses, or to avoid hazards that could lead to crop loss. Wheat is subject to many diseases but on the evidence of recent field experiences, two particular disorders need to be avoided, and this avoidance can be achieved by understanding the facts of (1) the foot-rot complex, and (2) damage to seed of low vigour.

When I say foot-rot complex, I mean that we are contending not with a disease of single cause and simple effect, but rather a composite debility of several causes, biologically independent but collectively bearing down on the wheat crop at all stages from the cradle to the grave—from sowing time to harvest. The chart portrays what I mean.

<table>
<thead>
<tr>
<th>Growth Stage</th>
<th>Disease</th>
<th>Cause</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seedling</td>
<td>Emergence loss, Seedling blight</td>
<td>(1) Soil fungi <em>Fusarium SP.</em> <em>Rhizoctonia</em></td>
<td>Grass roots and organic remains.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Toxicity of seed disinfectants.</td>
<td>Excess chemical on low vigour seed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3) Grass grub.</td>
<td>Insect pest.</td>
</tr>
<tr>
<td>Full leaf</td>
<td>Take-all</td>
<td>Soil fungus <em>Ophiobolus</em></td>
<td>Grass roots and preceding cereals.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[Brown foot-rot Take-all (white heads stage)]</td>
<td>Ditto.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eyespot lodging (Strawbreak)</td>
<td>Ditto.</td>
</tr>
<tr>
<td></td>
<td>Yellow dwarf</td>
<td>Virus</td>
<td>Aphid transmitted from oats.</td>
</tr>
<tr>
<td>Ripe Maturity and Earblight or scab</td>
<td><em>Fusarium SP.</em></td>
<td>Air-borne spores or fungus at base of stems.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Black heads (Blackening)</td>
<td><em>Cladosporium SP.</em></td>
<td>Air-borne mould as secondary infection on prematurely dried-off straw</td>
</tr>
</tbody>
</table>

The Foot-rot Complex in Wheat

- **Seedling**
  - Emergence loss,
  - Seedling blight
- **Full leaf**
  - Take-all
  - [Brown foot-rot Take-all (white heads stage)]
  - Eyespot lodging (Strawbreak)
  - Yellow dwarf
- **Ripe Maturity** and Earblight or scab
- Black heads (Blackening)
Satisfactory wheat yields depend on the success you have in avoiding this composite of trouble. The way to view the problem is in the sense of crop disorders produced by micro-organisms normally and typically present in soils. In fact the FUSARIUM fungi perform a useful function in assisting the process of decomposition of organic matter but, whereas they are self dependent on organic matter, they can and do under some soil conditions transfer their habit towards a disease-producing tendency on wheat in particular. This initiation of disease is influenced by soil conditions and an objective of some research in soil pathology is to define the environmental conditions that enhance the disease potential of these soil fungi. The essence of the matter in respect to foot-rot in wheat lies in crop rotation and how rotations serve to either check or encourage the development of disease-producing organisms in soil.

The foot-rot complex is likely to be most severe when wheat is grown as the first crop after ploughed grass, for the soil fungi referred to are able to exist saprophytically or as weak parasites on the root-and-leaf residues of virtually all cereals and grasses. Thus:

- Fusarium culmorum
- F. avenaceum
- F. graminearum
- Cercospora herpotrichoides

Recorded on 17 annually-occurring grasses.

On 10 grass species.

Ophiobolus graminis On 15 grass species.

It has been stated that “Take-all (Ophiobolus) has been present in the wheat fields of U.S.A. since earliest colonial days . . . . .” and other American records testify to the occurrence of this fungus in indigenous grasses. Under Australian conditions Adam (1951) has also described the experimental basis of our understanding of this connection between the Take-all and foot-rot diseases and preceding grass pasturage.

Cultivation for wheat as a first crop after grass should aim therefore to ensure that grass residues are completely disintegrated, and, in recent times, this has not been facilitated by the modern tendency to ignore what grandfather did and to do it much quicker. For instance, grandfather’s system in preparation for wheat followed this pattern:

Skim-plough early December out of grass.
Cross-skim late December.
Cultivate during harvest, especially during intervals when weather interfered with harvesting.

The grass being killed by the end of January, further consolidation occurred during this period of fallow.

Deep ploughing in April, for wheat sowing May-June.

The average wheat yield is better now than in grandfather’s day despite my contention that some preparatory cultivation might not be so good. So far as we can check, he had less trouble with disease under the system he used of soil preparation. If he had had the use of the improved varieties now available there would probably have been no margin of yield difference, for what he gained by absence of root disease, he tended to lose by the tendency of older varieties to shake grain, and to lodge, or to exhibit other agronomic deficiencies since rectified by notable advances in plant breeding.

In a survey, Miss Miller (1954), of the Department of Agriculture, found, in what she called the Christchurch “home” counties, that the best wheat yields were being obtained with the rotation where wheat was the first crop after grass—slightly more than given
by the rotation “grass: potatoes: wheat.” In another region though (Ashburton) the best yields over five years were derived from “grass: peas: wheat” rotation.

So we cannot unequivocally condemn wheat growing out of grass or within a year of grass ploughing, but farmers should be made aware, nevertheless, of the potential of disease arising from grass residues in some conditions. The crux of the matter clearly lies in the efficiency of preparatory cultivation. I believe that where claims are made for satisfactory results with a grass-to-wheat sequence, the cultivation procedure would have allowed for a summer fallow during which fortuitous occurrence of dry weather conditions would lead to dessication of fungus-infected grass roots. There is nothing new in that proposition. It was basic in wheat-growing in grandfather’s day but, as with some slow moving relics of the past, the idea has tended to be outmoded under the influence of speed. We know now, however, that control of foot-rot and root-rot is primarily dependent on cultivation which achieves the eradication of residue plants upon which the causal fungi are carried.

Soil-nitrogen levels under New Zealand wheat-growing conditions also appear to influence the onset of root and stem disease. Soil nitrogen is high after “grass: clover” and after “grass: peas” and frequently the early growth promise of wheat when following these sequences does not materialize in the form of good yields. It can be shown that brown foot-rot (FUSARIUM) and Eyespot (CERCOSPORELLA) build up in severity at the base of wheat crops developing under high-nitrogen conditions. Lodging occurs and well-formed ears fail to set grain. Both these effects are the result of interference with upward movement of plant nutrients in the stem, the base of which has been invaded by soil fungi favoured in their development by high soil nitrogen.

The field trials of the Department of Agriculture reported by Lynch (1959) have shown that the wheat crop responds to fertiliser nitrogen generally when wheat is placed in a rotation after two or more crops from grass, and Lynch suggested that the only place for nitrogenous fertilisers was when wheat followed a cereal crop and particularly on recent plains soils. It seems definite that where wheat crops are grown in rotation near to ploughed grass pastures which, under our conditions, have generally carried heavy sheep stocking, or have been dominated in composition by nitrogen-fixing clovers, the nitrogen level is more than sufficient. Indeed the nitrogen level then predisposes to soil disease. The position depends to an extent upon variety. Cross 7 is generally non-responsive to added nitrogen or, conversely, suffers severe stem disease under high nitrogen, whereas the varieties Hilgendorf and Aotea are not so adversely affected either by higher nitrogen levels or the corollary of stem disease associated with soil nitrogen.

We have shown to our satisfaction on the College farm that the stem-disease effect on high-nitrogen soil can be offset by oversowing onto wheat in spring a grass mixture—any cheap, low-germinating ryegrass for example. The grass in a normal summer grows at the base of the wheat plants, draws upon the reserve of soil and, in doing so, restricts the nitrogen level to the extent that the disease fungi do not develop to the detriment of wheat. This system of oversowing has other advantages such as supplying late-summer grazing after the wheat is harvested or by aiding the provision of organic matter when the cereal stubble and grass are eventually ploughed in.

Another cause of poor yield on occasions in recent years has been demonstrated to be the toxic effects of organic mercury disinfectant dusts when applied in excess amounts to out-of-condition seed. There
is every justification for continued disinfection of seed grain (Blair, I. D., 1950-56) but instances have been observed where dust loads in excess of the recommended 1½-2 oz rate have caused severe losses in field emergence and have led to development of stunted, deformed plants. This problem has been reported in detail elsewhere. (Smith and Blair, 1959). It has been shown that poor vigour, implying low interim germination, is basically the result of high moisture content of seed at harvest or in storage. Experiments have been described which show that when grain with a moisture content above 15 per cent is disinfected with the organic mercury at the 2 oz level or more, very marked reduction in germination and field emergence will occur.

Some other seed disinfectants, non-mercury materials, do not produce this form of germination injury and, in brief, it can be said that the evidence points to a change in our practice regarding disinfection of seed wheat. Where the dry-dusting method is used the recommendation is that either the rate of organic-mercury (Ceresan) be reduced to 1 oz per bushel, or that the thiram-type dust (Fernasan) be used at the 1½-2 oz rate.

REFERENCES
THE SIGNIFICANCE OF MOISTURE IN WHEAT


The importance attached to moisture in wheat comes principally from the effect of moisture content on the storage life of the grain. There is no difficulty in storing dry wheat for a year or more but damp wheat becomes useless within a week or two.

The effect of moisture content on the market value of wheat is plain; the miller does not want to pay for water and the farmer does not want to lose through his wheat being excessively dry. The practical miller objects to damp wheat for a further reason—it leads to the blockage of flour sieves and hence loss of production time, and beyond that we come back to the storage question—damp flour comes to ruin even faster than damp grain.

Moisture and warmth hasten deterioration

In any healthy seed there exists the means for carrying on a number of life processes. The process that affects the behaviour of wheat in storage is that of respiration. Viewed in a simplified form this has many parallels. An engine produces mechanical energy from the chemical process by which petrol reacts with atmospheric oxygen to give carbon dioxide, water, and heat. An animal gets heat and mechanical energy by the combustion of foods but instead of an explosion it uses a complicated system of bio-chemical tools—called enzymes—to carry out the process at body temperature:

\[
\text{Food} + \text{oxygen} \rightarrow \text{Carbon dioxide} \quad \text{Water} \quad \text{Heat (and other forms of energy)}
\]

The rate at which respiration goes on in wheat depends greatly on the conditions in which the grain finds itself. Table 1 shows the effect of moisture content on the intensity of respiration as indicated by the amount of carbon dioxide produced.

<table>
<thead>
<tr>
<th>Grain Moisture Content</th>
<th>Carbon Dioxide produced at 86°F. mg/Kgm.</th>
<th>% Germination after 20 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.6</td>
<td>1</td>
<td>95</td>
</tr>
<tr>
<td>13.8</td>
<td>2</td>
<td>95</td>
</tr>
<tr>
<td>14.5</td>
<td>5</td>
<td>92</td>
</tr>
<tr>
<td>15.4</td>
<td>25</td>
<td>91</td>
</tr>
<tr>
<td>16.3</td>
<td>234</td>
<td>67</td>
</tr>
<tr>
<td>18.5</td>
<td>1110</td>
<td>37</td>
</tr>
</tbody>
</table>

As it happens the enormous increase at the higher moisture content is due to the respiration, not only of the grain but mainly of moulds that are present as a rule in the outer tissues of normal healthy wheat grains. When wheat is grown under conditions where moulds are absent it shows a much slower increase in respiration with moisture content.
At the high respiration rates given for damp wheat heat is produced faster than it is lost under some practical storage conditions and the temperature of the grain rises. This means an increase in the rate of respiration (see Table 2) and consequently a further increase of temperature. The effect of this snowballing in the rate of respiration is that at moisture contents beyond the “safe” level there is a risk that grain will go towards ruin at an ever increasing rate unless something is done to take away the heat or lower the moisture content. It is not easy to foresee exactly how high the moisture content may be and yet be “safe” even for known storage conditions.

In New Zealand, 15 per cent is generally accepted as a safe moisture content for wheat, but even this might prove too high for wheat stored in very large bins. The presence of broken grain, non-viable grain or rubbish reduces the margin of safety; the cleaner the grain the safer it will be.

The best method of ensuring that wheat will store well is to get it dry to begin with, that is as it is harvested. Whether a wheat-grower relies on this method or on artificial methods for drying wheat harvested damp he will find it useful to know something of the key to drying—the relative humidity of air.

Relative Humidity (“R.H.”) of Air

Ordinary air is a mixture of gases, oxygen, nitrogen, etc., and one of these is water vapour. That we call it water “vapour” is only an historical accident—the water is there as a gas like the other constituents of the mixture. The important distinction of the water however is that it can change into the liquid state at ordinary temperatures whereas the other gases do so only at very low temperatures. As a consequence it is found that the amount of water that air can hold depends on the air temperature. If we know the temperature then we can say what amount of water the air will have when it has picked up as much water as it is capable of holding, i.e. when it is saturated.

The weight in grains of water to a pound of air at saturation, known as the “absolute humidity,” and also the percentage by volume of moisture in the air, are given in Table 3.

<table>
<thead>
<tr>
<th>Temperature °F.</th>
<th>Carbon dioxide produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>77</td>
<td>4</td>
</tr>
<tr>
<td>95</td>
<td>13</td>
</tr>
<tr>
<td>113</td>
<td>317</td>
</tr>
</tbody>
</table>

Consider the air at 70°F. When it is saturated and has 112 grains of water per pound its relative humidity is 100 per cent; when it has half of this weight, i.e. 56 grains, its relative humidity is 50 per cent. The percentage relative humidity expresses the amount of water in the air as a percentage of the greatest amount of water the air could hold at the same temperature.
A most important thing to learn from Table 3 is that the relative humidity of air can be reduced by warming the air. If the saturated air at 60°F. is warmed to 70°F. its relative humidity falls from 100 to about 69 per cent, since 78 grains is approximately 69 per cent of the 112 grains that air at 70°F. can hold.

Why this is important will be seen from the way grain moisture content is related to relative humidity.

Equilibrium Moisture Content and Relative Humidity

Table 4 shows the relationship that has been found in England to exist between wheat moisture content and the R.H. of the air amongst the grains measured when a steady state, i.e. equilibrium, has been reached. Similar results have been obtained by measuring the moisture content of wheat exposed for sufficient time to air having the relative humidity given.

<table>
<thead>
<tr>
<th>Air relative humidity</th>
<th>Wheat moisture content</th>
</tr>
</thead>
<tbody>
<tr>
<td>9% is in equilibrium with</td>
<td>6% grain moisture</td>
</tr>
<tr>
<td>45%</td>
<td>12%</td>
</tr>
<tr>
<td>60%</td>
<td>14%</td>
</tr>
<tr>
<td>66%</td>
<td>15%</td>
</tr>
<tr>
<td>72%</td>
<td>16%</td>
</tr>
<tr>
<td>81%</td>
<td>18%</td>
</tr>
<tr>
<td>86%</td>
<td>20%</td>
</tr>
</tbody>
</table>

The actual values given in the table may not be exactly right for New Zealand conditions and wheat varieties, but the table will serve to illustrate how drying can take place.

Drying of Crops in the Field

Consider a ripe standing crop with 16 per cent moisture in the grain on a day in which there is no direct sunshine. If the air relative humidity is close to 72 per cent, the moisture content will remain at 16 per cent for as long as these conditions persist. With an air R.H. of 60 per cent the grain moisture content would fall towards 14 per cent, and a Canterbury nor-wester at an R.H. of 45 per cent would bring the moisture content down to 12 per cent within a day or two.

A wind with an R.H. of 80 per cent however would reverse the process and the wheat would tend to gain moisture towards the 18 per cent mark.

Direct sunlight improves drying partly by warming the general air mass and hence reducing its R.H. (see under Table 3) and partly by heating the wheat ears and the air in close contact with them.

Air movement, as in a wind, hastens the attainment of equilibrium whether it be towards a lower or a higher moisture content.

| Moisture content of a thin layer of wheat freely exposed to air in barns |
|--------------------------|--------------------------|
| Lincoln | Invercargill |
| March | 14.3 | 17.1 |
| April | 12.0 | 17.5 |
| May | 13.7 | 17.2 |
| June | 15.7 | 16.5 |
| July | 17.0 | 15.7 |
| August | 16.2 | 16.5 |
| September | 15.8 | 15.7 |
| October | 14.0 | 15.7 |
| November | 12.0 | 15.7 |
Measurements of the air R.H. can be used to indicate what the drying conditions are from day to day but the easiest way of studying conditions over a long period is to observe the weight of a thin layer of wheat freely exposed to the air. Grain moisture contents calculated from the weight changes present the averaged effect of the varying air R.H. and also the moisture content towards which that of stored wheat will tend to move from time to time.

The figures for Lincoln mean that the average R.H. of the air in April, 1933 was low and that aeration of wheat would have taken its moisture content towards 12 per cent. By July on the other hand, no amount of aeration could take the moisture content below 17 per cent (unless the air were heated).

After July, drying of moderately damp wheat would not have resumed until about September.

As was to be expected the Invercargill conditions were worse than those of Canterbury.

The above data are too scanty in themselves to warrant generalisation about the climates in the two places but other evidence lends support to the general indications.

When grain is harvested damp into bags the drying rate in the summer is very much slower than for a standing crop even when the bags stand singly. The obvious cause is the restriction of air movement. In large stacks of bags there is very little change in moisture content unless provision is made for ventilation.

Records of the course of drying wheat in sacks are inadequate in quality and quantity but in 1938 F. W. Hilgendorf summarised his findings thus:

1. Wheat waiting for the header will fall one to two per cent in moisture per day during hot windy weather.
2. Wheat standing in single sacks in the field can dry up to two per cent in 10 days.
3. Certain methods of stacking sacks in the field (to encourage ventilation) gave drying of up to 1.4 per cent in five weeks.
4. Wheat sampled from the same sacks may vary four per cent in moisture content depending on whether the sample is taken shallow or deep.


A wet finger exposed to unsaturated air feels much colder than a dry one. In changing from liquid to gas the water absorbs a parcel of heat called latent heat which it takes from the finger and we sense the consequent fall in skin temperature. This cooling effect of evaporating water is the basis for the measurement of R.H. by means of dry bulb and wet bulb thermometers.

The wet bulb thermometer is an ordinary thermometer like the dry bulb but its bulb is covered by muslin kept wet by means of a wick. The lower the air humidity the faster water evaporates from the muslin and the greater the cooling effect on the thermometer owing to the carrying off of latent heat in the vapour. There are simple tables from which R.H. can be read for particular values of wet bulb and dry bulb temperatures. There are also "psychrometric charts" which show, in a simple way, how the R.H. and other properties of the air will change with addition or removal of water or heat. Anyone who intends to dry wheat artificially is advised to become familiar with one of these charts.

Latent heat has an important bearing on the drying of wheat, especially when the wheat is in a compact mass. With a ripe standing crop there is so much air available that it provides the latent heat if the conditions are suitable for drying but with grain in sacks or in bulk the air supply may be too low to both carry off moisture and bring in enough heat to make good that lost as latent heat. In this
case the latent heat comes from the grain which therefore falls in
temperature. This fall in temperature is also shared by the air
amongst the grains and the effect of this is to raise the air R.H. (see
Table 3) and hence reduce the tendency for drying to take place. In
artificial methods this has to be avoided—usually by heating the air.
It is very fortunate that in the wet bulb thermometer we have a
simple means of finding out the heat content of air.

**Bulk Wheat**

The important thing about bulk wheat storage on N.Z. farms is
that there is a lack of practical experience about it. A few farmers,
notably Sir Walter Mulholland, have harvested in bulk, but they
have not had to face conditions that would arise if bulk handling on
farms becomes general. On the other hand a great deal is known
about the behaviour of bulk wheat and how it can be safely handled
so there is no need to fear bulk handling merely because it is
unfamiliar to us.

As T. A. Oxley has pointed out, a mass of bulk wheat is not
likely to differ very much from a large stack of closely packed sacks
of wheat so far as heat transfer and air movement are concerned.
In either case, heat generated deep in the mass will tend to be
retained owing to the insulating effect of grain, and natural air move­
ment will be too low for much drying to take place.

In spite of this there are some reasons, as well as experience
elsewhere, to support the view that bulk wheat needs to be harvested
drier than bagged wheat unless drying facilities are at hand. First,
bagged wheat is usually left in the field for long enough to cool from
a high day temperature; second, if the wheat is not dry it can be left
standing in bags until it is dry. Bulk wheat on the other hand may
go into the bin very soon after harvesting and it may be warm enough
to initiate self-heating at a moisture content regarded as safe for
bagged wheat. Unless facilities are provided for “turning” the wheat
from one bin to another or for ventilating the bulk no drying can take
place.

**Artificial drying**

Over a period of 30 years the Wheat Research Institute from time
to time has gone into the question whether artificial drying of wheat
should be encouraged in New Zealand. In the past the answer has
always been that the amount of wheat lost through the lack of drying
facilities has not been great enough to justify expenditure on drying
equipment. This opinion seems to have been widely held, for the only
people advocating the installation of driers have been those who
would not have to provide the money. Wheatgrowers have, however,
acted on the view also held in England that one of the best means to
guard against a wet harvest is to have a large combine capacity so
that full use could be made of short periods of good weather.

There are now numerous methods of wheat drying in common use
in Britain. Amongst these are, (1) platform sack driers, (2) continu­
ous flow driers, (3) ventilation bins, (4) bin driers.

The Institute has carried out experiments on the platform-drier
method and on bin ventilation. The work on the platform method
was to provide data for an engineer to design a commercial installa­
tion near Christchurch. In this method sacks of grain are laid over
rectangular holes in a platform forming the upper surface of a large
box into which heated air is blown. The method had been used early
in this century but later came into wide use in Britain. In particu­
lar the experiments showed that the New Zealand grain sack was
equivalent in air resistance to about two inches of wheat.

The work on bin ventilation and bin drying was started in 1938,
that is, before the very thorough experiments and trials made in Britain that have brought the methods into common use.

N.Z. Experiments in drying Bulk Wheat

The Institute has made four bulk-drying trials. Three of them, made between May, 1938 and August, 1939, were to test a German proposal for ventilating across tall, square bins such as millers use. In the Institute's version, triangular air-shafts were formed in all four corners of the bin by means of wooden louvres sloping upward towards the corner so as to hold the wheat from filling the corner and at the same time present a surface of grain for air to enter or leave. Air was blown in at one corner and escaped into the other three corner shafts after passing horizontally through the grain.

The laboratory bin was eight feet square, but in height it represented only about three feet of a full-scale bin. Measures were taken to prevent the air escaping upwards or downwards and to give it freedom to move across the bin as it would in the full scale bin. The bin held about four tons of wheat, and the fan used was a one-third horsepower forge blower that delivered about 130 cubic feet of air per minute (c.f.m.) through the wheat against a back pressure equal to 1.4 inches of water.

The first trial was started too late in the autumn of 1938 and ventilation was applied very rarely until October. Thirty-eight hours of ventilation were given from 10 October until 5 December when the experiment was resumed in earnest. From then 112 hours of ventilation were given over a total of 16 days until 19 January. The significant moisture observations were 17.8 per cent in May, 1938; 17.3 per cent in October, and 15.8 per cent in January, 1939.

The moisture reduction of 1.5 per cent from October to January must have occurred mainly after December but it meant a power consumption of only 20 units over 132 hours of fan operation.

For the second experiment begun on 1 February, 1939 there was a better understanding of how to operate the bin. The wheat was put into the bin in a mouldy condition at 18.7 per cent moisture. Ventilation cooled it rapidly and the moisture content was down to 17.2 per cent by 8 February, and 16.4 by 24 March. Power consumption was 56 units for a total of 200 hours' ventilation.

The third experiment was made during the winter of 1939 and an electric heater was used to raise the incoming air temperature by about 18°F. The wheat, again about four tons, contained 17.6 per cent moisture when put into the bin. Ventilation began on 11 July. By 27 July the moisture content was 16.3 per cent and by 9 August 15.5 per cent. Power consumption was 222 units during 136 hours' ventilation, that is a load of 1.7 kw.

The idea behind these experiments was to bring about slow but cheap drying of wheat in a structure primarily intended for storage. In such a case the slowness of drying is of no account provided the wheat does not come to harm. In the first two experiments the wheat was mouldy when received but that in the final one was free from visible mould and remained so.

The conclusion drawn was that slow bulk drying could be carried out with unheated air during the summer in Canterbury and with heated air in winter.

Detailed observations made during the experiments showed that wheat remote from the air-inlet louvres did not begin to dry until the wheat nearer the louvres had dried to low moisture contents. A zone in which drying was taking place slowly advanced across the bin from the inlet. This has since been demonstrated by many workers elsewhere.

In the experiments wet and dry bulb thermometers were used to examine the air entering and leaving the bin. Ventilation was not
as a rule carried on unless the amount of water per cubic foot of the air leaving was more than that entering, i.e. there was a nett loss of water from the wheat. By this means the best drying days were selected and the bad ones rejected.

The cooling effect due to removal of heat as latent heat was strikingly apparent on many occasions and the heat supplied in the third experiment (in winter) was no more than sufficient to maintain the grain temperature at about 51°F.—an increase would have been beneficial. The beneficial use of the cooling effect is illustrated by the following observation made in the fourth experiment, made in 1945 with an improvised bin with floor ducts and holding 25 tons of grain. The wheat had been flooded and held 32 per cent moisture. After tipping, its temperature was 75°F. but this had fallen to 66°F. by the following morning after 16 hours' ventilation at a rate of about 10 c.f.m. per square foot. After 11 days the temperature was 53°F., and it rose again to 62°F. when ventilation was stopped for a few hours. The depth of the grain was six feet.

Observations made during the experiments confirm the English finding that observed variations in R.H. during an average day are due to temperature variations and that the absolute humidity is usually constant for the day. This simplified operation of the bins.

Another simplifying factor was that the air leaving the bin was at the equilibrium R.H. of the grain near the outlets and it changed only slowly in humidity and temperature.

With present-day equipment and knowledge, ventilated bins could be operated better than in the Institute's experiments, but one thing is clear. The operator should take the little trouble needed to understand a psychrometric chart so that his thinking will not be impaired by unnecessary mysteries about what is going on.

The U.K. methods that Mr Crosbie describes are based on adjustments of R.H. alone to 65 per cent or less by heating the air and the use of high ventilation rates. It seems likely that the more favourable harvest and air conditions, at least in Canterbury, would allow lower rates to be used in New Zealand than in Britain, and this has some support from the Institute's experiments.

Can the Millers Take Bulk Wheat?

Farmers who propose to handle their wheat in bulk should make advance arrangements for its disposal. Some millers will welcome a certain proportion of bulk wheat provided it is dry, but there may be no more than one who could accept damp wheat. This means that bulk harvesting without farm storage and drying facilities should not be undertaken lightly—it might mean disaster in a bad season.
BULK HANDLING AND STORAGE OF GRAIN

(i) A. L. Mulholland, Darfield.

Some 28 years ago, my father purchased one of the first American header-harvesters to be used in this country. The firm from whom he purchased this machine actually imported two, one a bagger and the other a tanker. My father, even then, realised the advantages of bulk handling, and decided to take the latter. We have had three machines since that date and all have been tank machines.

From 1930, until 1952, a variety of methods were used to bag the grain at the barn. In 1951, Australian wheat exporters decided that all wheat was to be exported in bulk. This meant that mills in New Zealand had to hastily equip themselves for bulk handling. This also meant that facilities would be available for the handling of wheat in bulk from the Canterbury farm. My father had a double role in this venture. As a member of the Wheat Committee he and others were responsible for making arrangements with the mills and the railways, and as a farmer he consigned the first bulk wheat from farm to mill. I would like at this stage to pay a compliment to the Railways for their wholehearted co-operation in this venture since its inception. Their handling of the last harvest was excellent in view of the much greater area in crop, and the unprecedented rush due to the dry summer.

Equipment

On our farm we grow annually about 300 acres of grain crop, apart from small seeds. Our equipment consists of a John Deere "55" 12-foot self-propelled combine, fitted with a 45-bushel grain tank. The tank is emptied with a high-capacity unloading auger, which can unload the 45 bushels in 55 seconds into a moving truck. We use our five-ton farm truck which has a hydraulic tip. The deck is made of ship-lapped timber to prevent grain leakage. Sides and tail board are also ship-lapped timber and are 27 inches high. The truck can carry 200 bushels without overflowing, although a normal load is 150 bushels.

At the rail siding we use an imported American grain loader of the paddle type. This machine can handle up to 1500 bushels per hour, and can elevate to a height of 30 feet. A 15-bushel hopper at the base of the elevator can be replaced by a 12-foot auger which lies flat and can be used through tunnels in the base of a silo or storage bin for loading out purposes. The auger is driven through a double universal joint which enables it to swing through an arc of 90 degrees. This allows the auger to follow the receding grain heap.

The final piece of equipment is one we have built up ourselves. It consists of the 45-bushel tank from our old original combine. We built it on to a trailer, pulled behind one of our light tractors. The unloading auger on this tank is driven from the tractor power-take-off. We call this our field hopper, and it receives the tankful which is threshed while the truck is away.

In the early days prior to complete bulk handling, we used to cart the grain in bulk to the granary and bagged it there. We used a variety of methods which need not concern us here. In 1952 we railed some 6500 bushels using a home-made elevator, and gravity-unloaded hopper on the truck. The next year we purchased the bulk elevator which we still use. That same year we fitted an auger into the body of the truck, driven from the truck's gearbox. We used this for two seasons, and then changed to the hydraulic tip. This is the most satisfactory method.
We start off by threshing and loading into the truck, three header tankfuls, or about 150 bushels. Although the tank on the header holds 45 bushels, by taking the load from the header on the move, another three to five bushels are added during discharge. The truck goes off to rail. The next tankful is placed into the field hopper by the header driver. By the time the header tank is filled again, the truck will be back from the station to receive it. Then the truck moves over to the field hopper and takes the load from there. Soon after this the header will have filled again and the truck will be back to receive its third tankful, and so it goes on. The round trip to rail with an average haul of two and a half miles takes about 15 to 20 minutes, ten minutes travelling, and five to seven minutes to unload into the railway waggon. By this system, we find it possible to maintain a non-stop run, with no lost time.

Some idea of what can be done may be seen from the following figures. One day last harvest, my brother and I headed and carted the grain to rail from 40 acres of Arawa wheat. We filled four LC wagons with 2015 bushels in ten hours on the header engine hour-meter. We had no outside help except to sheet the wagons down at the end of the day. As a matter of interest we used 26 gallons of petrol in the header and about eight gallons in the truck. I believe we could, under ideal conditions, handle 2500 bushels in a day of ten or twelve hours. Our best effort on the header has been to fill the tank in eight minutes, or about 360 bushels per hour.

Oats, of which we grow 40 to 60 acres per year, are handled in much the same way except they are loaded into a steel silo with a capacity of 2000 bushels. Another wooden silo, built inside the granary, holds a further 1000 bushels. We have sold oats in bulk on four occasions to a Christchurch grain store for seed purposes. We arranged to send one LA waggon per day, which they unloaded straight into their dressing plant. On other occasions we sold the oats in sacks. By fitting a two-way bagger to our elevator and closing the machine down as slow as possible, we fill sacks straight on to the lorry. The sacks come off at the rate of one every 20 seconds, and can keep two good bag sowers very happy.

One of the problems facing the would-be bulk handler, is what to do with small seeds and other crops which have to be bagged. We have used two methods. One is to cart the grain into the granary in the same way we used to do before the advent of bulk handling, using the elevator with the two-way bagger. Peas, of which we grow between 40 and 80 acres, are prone to splitting in the unloading auger, thus damaging the sample. For this reason, they are not very suitable for bulk handling. Grass seeds and clovers don't lend themselves to bulk methods either.

This brings us to our second system. My brother and I designed and built an auxiliary bagging platform on our header. This does not interfere with the grain tank in any way. A Skour-Kleen screen which was original equipment on the machine proved unsatisfactory, and we replaced it with a screen from another machine after rebuilding it so that grain could be screened into the tank or bag. An auger along the bottom of the screen carries the screenings across to the bagging platform. Another auger alongside brings the firsts across, and can be short circuited into the tank by removing a deflector. The platform is served by a bag chute of conventional pattern. I cannot give any idea what the cost of these modifications would be as my brother and I did all the work ourselves.

Storage
This is the part which presents some problems. As last harvest showed us, the mills simply cannot cope with the crop at the height of the season. Most country railway stations have not got room to handle more than one or two operators at a time. Therefore farm storage of some of the harvest is essential. As I have said, we have
had considerable experience in storing oats in bulk. Due to the thick husk, which can absorb a lot of moisture, storage of this grain is relatively safe. Wheat, however, with its 15 per cent limit, is not quite so easy.

Our first attempt at storage was to use a lean-to type of shed. We closed it in and strengthened it with truss wires at intervals along its length. Several sheets of iron were removed from the roof and the grain poured in through the resultant holes. This proved quite satisfactory from a storage point of view but not so easy to load out. A lot of handwork was necessary when it came to loading out. Five years ago, we built a wooden-walled silo inside the granary, holding 1000 bushels, and then three years ago we built a 2000-bushel prefabricated silo imported from Australia. This consists of a cylindrical building constructed of 16-gauge corrugated iron. It is 14 feet in diameter, and 18 feet high. We like this type of silo best. It is used almost universally in Australia and the U.S.A. We would like to erect three more of these by next harvest. However no import licenses have been granted for them so it looks as if we will have to try something else. We have studied a number of overseas drying methods, and it would seem that we will be able to dry wheat in Canterbury by blowing ordinary unheated air through it with a big fan, provided the relative humidity does not exceed 65 per cent. We purchased such a fan some years ago in case we ever have to store wheat but have not used it as yet. If we build these silos, air ducts will have to be incorporated in them to take the air from this fan which has a capacity of 6000 cubic feet per minute against a six-inch water gauge. It is worth while remembering that while the safe moisture content for storing is 15 per cent, wheat can be stored for a week or so at 17 or 18 per cent.

To sum up, I would say this. Farmers contemplating this method would do well to remember these considerations. Does the area in crop warrant the change? A reasonable area, say 100 acres of grain should be grown so as to keep down the overhead. A well equipped workshop and the ability to do your own engineering are a big help in keeping down equipment costs.

If these conditions prevail, then there is nothing to stop any farmer handling his grain in bulk. It is a mighty easy way to harvest.

(ii) E. S. Johnstone, Methven.

I would like to express my very great appreciation to the numerous people and organisations who have been such a help during the short time I have been threshing grain in bulk: The Malting Company, for all the advice and encouragement they have given, sometimes with considerable inconvenience to themselves; the Railways Department, and particularly the Station Master, who has gone out of his way to see that the system has run smoothly; Burnett’s Motors for their efficiency and careful co-operation. Without the help and understanding of these people we could not have handled the job so quickly and smoothly and each time without a hitch.

Reasons for Changing to Bulk

First, I wish to make it clear that I have not grown wheat since starting bulk threshing, but only barley. This is solely due to farm policy. Briefly, our main trade is sheep and cattle; 200 acres are in turnips each year. When this ground is clear of turnips it is immediately grubbed to a seed bed when the whole area is sown down with barley and certified grasses in the spring.

It was our climate which finally decided me to thresh grain in bulk. We have a rainfall of about 42 inches per year and so, you
can see, in any circumstances the job is not easy. Where we bagged off the combine in the usual way, we were creating an extra hazard by having many hundreds of sacks of grain out in the weather; this entailed a lot of extra work and worry trying to keep the grain in condition after we had got it into the bags. The logical step was to devise some method to eliminate as many of the hazards as possible, and the thought of having no sacks of grain to cope with after the threshing was finished appealed to me. You can see from what I have said that my theory has worked more or less contrary to the general belief that bulk handling is only successful in a dry climate.

But, whatever method used, the grain must be fit for threshing, and when it is we must go flat out. Bulk handling certainly helps in this respect. I have no doubt that many of you this year would have liked to be dealing with a moisture problem such as we were confronted with, but fortunately with our grain it was not as bad as usual.

Now as regards equipment, firstly we have a combine fitted with a bulk tank instead of the screen. We use a self-propelled machine. The tank holds about one ton of grain and is emptied by an augur which is driven from the combine engine. This is all part of the tank attachment. Next we have two bulk tanks mounted on trucks or trailers. Both these vehicles must be able to tip. And finally we have two grain elevators.

I will now describe in detail this method which, briefly, is a sequence of events, in order that you may see why each of the above pieces of equipment is necessary. Each one plays its part in a continuous flow system from standing crop to rail.

Method

Two men can handle this whole operation, but we usually work with three. The combine starts into the crop and as the tank becomes nearly full, the tip-truck which operates between paddock and rail pulls along side the combine (both vehicles still moving along). When the vehicles are lined up, the combine operator pulls the lever which sets the grain-tank augur in motion and this transfers the grain from the combine to the truck. It takes about half a minute to release one ton of grain.

This process is repeated until the tank on the tip-truck is full. The truck immediately leaves for rail and on arrival it is backed into the grain elevator which in turn is aiming immediately over an L.A. rail waggon. The lorry is tipped at an angle at which the grain will flow freely, the elevator is set in motion, the operator opens the grain chutes at the rear of the tank on the lorry, and by means of a slide regulates the flow of grain into the elevator. It usually takes about 20 minutes to empty the lorry.

On returning to the paddock the lorry driver finds that the tip-trailer which has been placed by the standing crop is almost full. It holds about four tons of grain. He pulls alongside the trailer with the truck next to where the combine will come round, tips the trailer, sets the second elevator in motion and places it where it will transfer the grain from the trailer to his truck. While this is going on, the combine can transfer its grain from the other side of the truck at the same time. The trailer tank also has a chute to regulate the flow of grain to the elevator.

This process goes on as long as the grain is fit, both day and night if possible.

We have to be very careful to see that the grain does not contain more than 15 per cent moisture, otherwise as you know, the sample will be rejected due to heating. We have found that on a
good drying day the moisture will drop from 15 to about 13 per cent during the process of handling.

The average weight of barley we can get into an L.A. waggon is about eight and a half tons. These are all double sheeted before they are consigned as excess moisture is our worst enemy.

At the rail head we have our own rake of trucks on a part of the siding reserved for us, and as these are filled they are consigned by the Station Master, which is much appreciated and saves us a lot of time.

Our output of barley for the last two seasons under this bulk system has been about 120 tons per year, and this takes us between three and a half and four days to complete.

It is a wonderful feeling to see the truck unloading for the last time, even at 3 a.m., and knowing that the job is completely cleaned up.

I am prepared to admit that this system has its limitations and is vulnerable up to a point, but under no circumstances would we have to cease operations unless it was the combine which broke down. In the case of a breakdown, or shortage of rail trucks, the chutes which I mentioned on the two grain tanks are both designed in the form of double baggers. In order to carry on, the grain could be bagged and stacked, as was the case with the big mills, and covered in perfect safety.

Another difficulty which would have to be overcome would be the congestion at rail if a number of farmers wanted to bulk-handle by this method. It is my intention before next season to make arrangements for storage on the farm, and I am now in the process of working out a simple method of doing this which will be suitable to our conditions.

Handling Other Crops

With the bulk combine we have threshed many other crops which cannot be sold in bulk, but have to be bagged. Last season we threshed 800 sacks of oats, 350 of ryegrass, and some white clover and lucerne.

The method used is very simple, and still only requires two men. During the first cut of the combine the trailer, as mentioned before, with the four-ton bin is set up, and tipped at a suitable angle for whatever grain is being threshed. When the combine comes round it stops at the trailer and empties into the tilted bin. The man at the bag hole at the rear of the bin can now start bagging.

As the bags come off they are stacked, as with the old mills. Usually when the heap has about 150 bags, the trailer is moved nearer the standing crop in order to minimize the distance the combine has to travel. When the paddock is finished there may be five or six heaps of sacks. These are covered and remain there until they are carted.

In the case of clovers there are not many bags, so they are not stacked but carted to the shed. One man on the combine can do the clover on his own. Sewing bags while standing on the ground is very much easier than sewing on the combine. One gets his exercise by lifting bags on to the heap. This could be done mechanically if desired.

To sum up, I would say that by bulk handling the job both in time and effort, can be cut in half and therefore, the risk of loss is considerably reduced.
I am farming with my son on a property of 600 acres. Our cropping programme for the year just past amounted to 90 acres wheat, 70 acres barley, 50 acres ryegrass, and 20 acres red clover seed.

Since I started in 1931 with headers for harvesting I have not been very happy leaving sacks of grain in the stubbles, at the mercy of the weather and the risk of fire. In 1936 I had 900 sacks of wheat flooded, some of them in a foot of water, which caused a tremendous amount of work and also a huge loss of grain. Since then, I have given the handling of grain from headers quite a lot of thought. However, as I did a fair amount of contracting until a few years ago there was not very much I could do about it.

It was again brought home to me in the harvest of 1957-58 which as you may remember, was a very slow, catchy one. My man left in the middle of January and from then on we were running short-handed most of the time, which made the going very slow. After the first week in February, the wild ducks came in hundreds every night; so in one way and another we lost quite a lot of grain. We always windrow the barley, so besides what they ate, they tramped down the windrows, causing sprouting. However, with all these worries we managed to harvest all the grain that season at round about the 15 per cent moisture mark. Had we been bulk handling, we could have brought the grain in at full capacity of the header and bagged the next morning while waiting for the crop to get fit. By this means we could have saved every bushel; of that I am sure.

Although I believe bulk handling of wheat and barley from farm silo to mill or rail head will become general in the near future, we decided for the first year to bulk only from paddock to our own granary. The grain is bagged from the silo inside the granary. Here one man working about ten hours a day, with perhaps a little help in the mornings before the header starts, could quite easily keep pace with the grain coming in.

As the bulk delivery of grain comes into its own, we intend to put in more silos, but all the silos will have a bagging spout as there are seeds such as ryegrass, oats and peas that must be bagged and will have to be for quite a long time to come.

To shift the grain from the header we built a bin of tongue-and-groove pinus, with 3 x 2 supports. This bin was fitted on the deck of a truck; it is four feet high, six feet wide and has a sloping floor down to deck level. At the rear it has two spouts fitted. These are also fitted with bag holders so that grain can be bagged from the truck if so desired.

When the truck comes in with a load of grain it is backed up to a hopper that is set on the ground. Unloading takes about two minutes, so the truck has ample time to return to the paddock for the next load of 45 bushels.

From the hopper to the silo the grain is elevated by a four-inch auger geared to lift the grain at the same capacity as it is coming off the header.

The silos were both made in the farm workshop. One was made of pine tongue-and-groove flooring, with 3 x 2 supports bolted together to form an octagon shape with tongue-and-groove boards nailed on the inside.

As an experiment, the other silo was made of three-tenths of an inch plywood. Four sheets, each eight feet by four feet, were used to complete the circular cylinder. First we cut a quarter of an inch to nothing off both ends of each sheet, to allow one side of the cylinder to fit inside the next and so make a snug joint. If the silo was for use inside a shed away from the weather, cutting two inches off
one sheet is all that would be necessary, the smaller cylinder being placed in the centre of the other two. The sheets were then bolted together with eight-inch strips of plywood, then given a good wetting and bent round until the two ends met and bolted, making a cylinder 32 feet in circumference. These cylinders were then placed on top of one another, with a four-inch lap and bolted making the silo eleven feet four inches in height.

Both silos stood up to the strain quite well, especially the plywood. It has shown no sign of weakness whatsoever.

At the finish of harvest the silos were left full of wheat with a moisture test of 12 to 15 per cent; after three weeks a sample was taken from the centre of the silo which gave the test of 13.8 per cent; about four weeks later another sample was taken given exactly the same test.

In conclusion, let me compare the last two harvests. In the 1957-58 season, at one time we had 1,500 sacks of barley out in the paddock waiting for transport. Owing to the dampness of the ground and the frequent showers, these sacks had to be turned every day. Last harvest, under bulk, when the header stopped at night every bushel was under cover and safe. This was done with the same amount of labour—one man on the header, one man with the truck, and the third man bagging under ideal conditions in a cool granary away from dust and without being tossed about on the header.

(iv) C. J. Crosbie, Department of Agriculture, Christchurch.

Bulk harvesting is not new. It has been practised overseas for many years and some of the first headers imported into New Zealand in the late 'twenties had tanks in them from which grain was discharged into bags when necessary.

In 1930 Sir Walter Mulholland purchased a Holt Model 38 bulk header and commenced bulk heading operations in that season. He changed over to a Massey Harris 726 bulk header in 1949 and to a John Deere 55 bulk machine in 1954. It is due to the foresight and initiative of Sir Walter Mulholland that we have evolved in Canterbury a system of bulk grain harvesting that is possibly the acme of farm mechanisation. He can rightly be called "the father of bulk grain harvesting in New Zealand."

Mr G. C. Warren of Darfield purchased his John Deere Model 55 bulk header in 1954 and in 1958 two further machines commenced work—a Massey Harris 780 Special for Mr E. S. Johnstone of Methven and a John Deere Model 55 for Mr W. J. Fletcher of Willowbridge. This season saw two International Harvester Model 101 bulk headers working for Messrs L. F. Chamberlain of Dunsandel and N. F. Kingsbury of Wakanui.

Bulk Harvesting

Thus, of approximately 2,400 header harvesters working in the Canterbury Land District, six are self-propelled bulk headers and it was my privilege to view them all at work last season. I saw a beautiful picture of crop mechanisation. On each of two farms over 100 acres of grain were harvested by two men—one man on the bulk header and one man on the farm tip truck taking the grain to the rail siding where it was elevated into railway wagons and sheeted down.

In one day of ten heading hours, two men completed the harvest of a 40-acre field of wheat averaging 50 bushels per acre. That night 2,015 bushels (approximately 50 tons) were sheeted down in four
railway wagons and the heaviest physical work was to lift a can of petrol into the header.

When the header pulled out of the field that night, the harvest was completed, the grain was on the rail and the cheque was as good as in the pocket. If the stubble burnt there were no sacks to burn; if it rained there were no sacks to turn. They could burn off and plough the field on the morrow or turn the sheep on to it as required. Two men did this at an average harvesting rate of five tons per hour maintained throughout the day, a rate that normally takes three good men to sew the bags on the platform of a bagging header.

The advantage of a bulk header lies in the speed and ease of harvesting (one man on the header instead of four) and the completeness of the harvest; the grain is off the field instead of in bags all over the field. The bulk header costs approximately the same as a self-propelled bagging header—about £3,000 for the medium models and £4,000 for the large ones. It is a little cheaper than the bagging model if no screen is fitted to the bulk machine and a little dearer if a screen is fitted to assist in the harvesting of small seeds. These machines can be and have been used to harvest all crops.

At a demonstration recently, I saw a team of 11 men with a traction engine and a big mill threshing from the stack and I understand that an average run in the old days was in the order of 2,000 to 2,200 bushels per day. In the 'twenties a traction engine cost approximately £1,200 and the big mill about £1,000. Thus, the picture of farm mechanisation changes.

Farm Storage

In the past, the grain from these bulk headers was, in the main, sent straight to the mill via rail or road transport. Such a system is workable only when the transport is available, and when the farm is close to a station or a mill. Whilst these farmers have received the closest co-operation from the Railway authorities in the past, they nevertheless anticipate some difficulties next season when it is expected that the wheat acreage will increase from 130,000 to 200,000 acres. Accordingly, they all intend to store a major portion of their grain harvest on the farm until such time as the public transport systems become readily available. It seems to me that the following will be the system likely to be followed.

Wheat

The wheat will be bulk headed and if it is harvested at 15 per cent moisture or less it will go straight into the bulk bins in the farm granary. If it is harvested above 15 per cent it will go into the drying bins, be dried down to 15 per cent and then go to the farm storage bins. Once the wheat is in the bins at 15 per cent moisture or less it can come to no harm and its costs nothing to leave it there several months when the maximum increment per bushel pertains for farm storage. Then, by arrangement with the mill manager, it can be sent to town at a time when there are ample transport facilities available and ample room in the mill because of the space created by its daily milling capacity. Undoubtedly, an odd truck lot will be railed direct from the field (at 15 per cent moisture, otherwise our bulk mills would not accept it because they have no drying facilities) to obtain some revenue to meet current expenses.

Such a system would obviate the hurry and bustle usually associated with the wheat harvest.

Barley

The barley harvest will follow much the same lines except that the malting industry wants the barley delivered into store as soon as possible where it will be dried down to 12 per cent moisture and stored
in bulk for a period of up to 18 months. It is likely, therefore, that bulk barley will move from the farm just as soon as transport and storage facilities are available.

Grain Drying

There is a relationship between the relative humidity (R.H.) of the air in the intergrain spaces and the moisture content of the grain. After a period of rest, the two are in balance according to a curve that has been determined by a number of workers. Thus, air of 65 per cent R.H. is in balance with grain of 15 per cent moisture. If air of 65 per cent R.H. is passed through grain of high moisture content, water from the grain is liberated into the air and drying takes place until the grain reaches 15 per cent moisture. This is the principle used in grain drying and, of the several different types of grain driers available overseas, in-bin drying is regarded as the most economic when only a few degrees of moisture are to be removed from the grain. This system uses a relatively low flow of air to accomplish the drying in a long period and has the advantage that the same unit can be used for storage. The British recommendation for this type of drier is a minimum air flow of 15 cubic feet per minute (c.f.m.) per square foot of bin floor area.

Heaters

If the R.H. of the ambient air is above 65 per cent, then it can be reduced to the required level by heating it, and this can be done by utilising waste heat from the engine, by an oil or coke heater or, more likely in New Zealand, by electrical means. From a psychrometric chart it is possible to determine how many degrees F. the air has to be heated to lower its R.H. to 65 per cent and from a graph it is easy to determine how many kilowatts of heater must be switched on to raise any volume of air to this required temperature. Usually a maximum of 10 deg. F. rise will effect the required reduction in R.H. and for a 4,500 c.f.m. air flow, this will require 15 kws of heating.

Actually, the heater is not likely to be used much in Canterbury where the hot nor-west winds often have an R.H. of 30 per cent. Nevertheless, the use of a heater in wet seasons when drying will be required most, should not be overlooked.

Canterbury Weather

The weather enjoyed by any district in January and February of any year will determine how much heating is required to condition the ambient air for grain drying should this be necessary. Accordingly, the following figures supplied by the Director of the New Zealand Meteorological Service are of interest. (Remember that air of 65 per cent R.H. is in balance with a moisture content of 15 per cent in grain).

The mean 24 hour R.H. (%) at Christchurch Airport

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The mean R.H. at Christchurch Airport for hours 7-18

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No. of days per month with R.H. less than 65 per cent for six or more consecutive hours at Christchurch Airport

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At Wigram, analysis of the hourly R.H. for a period of ten years shows that in January the R.H. is below 65 per cent on an average of eight hours per day and in February on an average of seven hours per day. The average daily R.H. was 74 per cent for both
months with a lowest hourly R.H. of 15 per cent recorded in January of 1941, 1943 and 1948.

From other tables it is evident that northern and inland districts experience drier weather than Christchurch whilst it is about the same or damper in South Canterbury districts. It would thus appear that in a normal year one may expect a considerable number of days in January and February when the R.H. is 65 per cent or lower for six to 12 hours and no heating will be necessary in this period of the day. The average R.H. for the whole day in January and February is about 72 per cent in a normal year and a three to four degree F. rise in ambient temperature would correct this—approximately four kilowatts of heating for a 4,500 c.f.m. airflow. In a damp season it would appear that about twice this amount of heating would be necessary.

By way of contrast the average R.H. in Britain for August and September varies from 77.5 to 85 per cent.

Fans

The backward-tipped, centrifugal fan, because of its non-overloading characteristics, is widely used for grain drying and when fitted with a limit-load motor will accommodate varying loads as are experienced with partially filled bins. The axial-flow fan also has limit-load characteristics for part of its range and can be used for pressures up to about three inches water gauge. For higher pressures, two state axial flow fans are needed and the capital cost is approximately doubled.

The size of the fan used will depend on the amount and depth of the grain being dried. Thus, if 60 tons of grain is to be dried in two 30-ton bins of a total of 300 square feet floor area at the recommended rate of 15 c.f.m. per sq. ft., then a 15 x 300 or 4,500 c.f.m. fan is required. If the grain is 10 feet deep in the bins there will be a resistance equal to say four inches water gauge at this air flow and a fan delivering 4,500 c.f.m. at 4in. w.g. will absorb approximately four horsepower.

Such a fan running continuously for 24 hours a day delivering air at 65 per cent R.H. would take just on a week to dry 60 tons of grain from 18 per cent to 15 per cent moisture, i.e. a three per cent moisture removal or about one half per cent of moisture per 24 hours’ drying. It is not anticipated that gain will be harvested above 18 per cent moisture except under exceptional circumstances. (It takes 13,500 c.f. of air at 65 per cent R.H. to remove one per cent of moisture from one hundredweight of grain.)

Ventilating at a low rate say eight c.f.m./sq. ft. results in a smaller fan (2,400 c.f.m.) and because of the lowered resistance due to the smaller air flow through the grain (1.75 in. w.g.) it will have a smaller power requirement (one horse-power) but will take nearly twice as long to do the same amount of drying—approximately a fortnight.

To run a one horse-power electric motor for a fortnight, buying power at 2d per unit, costs approximately 42/- and to run the larger motor (four horse-power) for a week costs approximately 90/-. It is felt that this small increase in power cost is warranted to release the drying bins a week earlier to enable the harvest to be continued, especially when the extra capital cost of the larger fan and motor is not great (say £40).

Ducting

Whether the main duct is laid above or below the floor it should be of such a size that the air speed in it does not exceed 2,000 feet per minute in order to reduce resistance losses. For the above fan of 4,500 c.f.m., the duct would be 4,500 divided by 2,000 or two and a half square feet in section.
If the duct is made of concrete or brickwork and built below the floor, there is no appreciable heat loss from the air.

**Bin Ventilation**

For in-bin drying, the bin can be fitted with a perforated floor laid on bricks on their edges or on two sets of floor joists laid crosswise. The floor can be of perforated metal with 1-8th or 3-32nd inch holes, a special grade of expanded metal, wedge wire or perforated plywood (1-8th inch holes).

An alternative scheme is to lay wooden ducting on the concrete floor with a main duct across the centre of the bin and smaller lateral ducts at about 18 inch centres. All ducts are laid on spacers to allow the air to escape under their lower edges and are of sufficient size that the air speed does not blow grain along their length and so block them. Grain entry to the ducts can, if necessary, be prevented by fitting wire gauze along the openings.

**Grain-Handling Plant**

In the field, bulk grain is discharged from the header into farm trucks or trailers—both with hydraulic tip trays on which the sides have been extended upwards to accommodate the bulky load. (One bushel equals 60 lb wheat, which equals 1.2 cubic feet; 46 cubic feet equal one ton wheat.)

At the granary, the contents are tipped into a grain pit which should be big enough to take the truck load and have sides sloping at 45 degrees. If below ground it should be moisture proofed.

An auger elevates the grain into the pre-cleaner where impurities and green material are removed and another auger elevates the grain into the drying bin if desired or it may be cross-conveyed to the storage bins if it is of 15 per cent moisture. Belt and bucket elevators may be used in place of augers, and conveyors can be of several different types—chain and flight, wire and scaper, flat belt, jog troughs or screw conveyors. Grain may also be elevated and conveyed in ducts by pneumatic means, but the horse-power requirements of such systems are well above alternative methods.

A four-inch auger when laid horizontally conveys approximately 12 tons per hour and the discharge falls off as it is raised so that it does about five tons per hour in the vertical position. A half horse-power electric motor is used for four-inch augers eight feet long and one horse-power motors for longer augers.

For loading on to railway trucks or road-transport vehicles, New Zealand farmers have used a variety of machines. A bulk lime loader (£1,300) was used at a rate of 30 tons per hour. Similar rates are achieved with chain and paddle elevators (£700) and a six-inch auger (£300 second-hand). A home-made nine-inch auger, the "Fletcher," achieved a higher rate, cost £160 and would seem to have great promise in this field. The auger needs to be 15 feet long to discharge into the centre of a railway truck. It should retail below £200.

The pre-cleaner is a unit that is new to New Zealand. Our nearest counterpart is the seed-dressing plant which is capable of finer work than that needed in grain cleaning. A pre-cleaner removes impurities and green material from the grain at a rate approaching that at which it is harvested, up to say five tons per hour. To my knowledge, pre-cleaners as such are not yet on the New Zealand market, but they will shortly be available.

Foreign matter in grain that is to be dried is undesirable because it tends to retard the air flow and increase the resistance against which the fan is working. Green matter is highly undesirable for two reasons. First, it costs money to dry this non-saleable product, and second, as it flows into the bin, it collects together to form masses.
which impede air flow so that pockets of grain are not completely dried. These pockets can heat up to give rise to "hot spots" which encourage mould growth so that quality deteriorates.

In wet years, when the drying plant is required most, the thistle and weed growth in grain crops is highest and is threshed with the grain. The header, even with a top screen, is unable to remove it all, so that green material is present in the threshed grain. Accordingly, the provision of a pre-cleaner to rectify this should not be overlooked in the design of a grain drying plant.

**Technical Instruments**

A pre-requisite of grain drying plants is a moisture meter to determine the moisture content of the incoming grain and to check on the process. They are available in several forms at varying degrees of efficiency at prices from £20 to £70 each. At this stage it would seem good policy to invest in one of the dearer, more accurate, electronic quick-testers as used by commercial firms and thus arrive at an amiable decision as to what is the final moisture content of the grain exposed for sale. A set of wet and dry bulb thermometers is required to establish the relative humidity of the ambient air and the same or a hair hygrometer for the air in the ducts. The temperature of the duct air is measured with an ordinary thermometer and its pressure with a manometer (homemade from a length of clear plastic tubing bent into a "U" and a school ruler).

A grain thermometer is used for recording temperatures in the bin and a grain spear enables samples to be taken from any part of the bin for moisture analysis.

In all, a sum of up to £100 can be set aside for the purchase of technical instruments and the £5 charged annually as interest against this purchase is but small insurance on 100 tons of wheat worth £2,700.

**Grain Bins**

Overseas tests indicate that bulk bins can be built from all the usual building materials—steel (either plate or expanded), aluminium concrete, wooden planking or plywood sheeting. Bins can be round or square, the latter being more economical of floor space but the walls requiring heavier construction are generally more costly. Bins are usually flat-bottomed, but can be made self-emptying with a hopper bottom. However, the extra expense and accompanying loss of storage space is usually not justified.

Bulk-bin construction requires a knowledge of the forces exerted by bulk grain if bin collapse is to be avoided. Bulk grain exerts two forces on the bin walls—outward thrust due to its weight and angle of repose and a downwards compressive force on the walls due to the friction between the grains and the walls. The magnitude of these forces is known and may be obtained from tables for different grain depths. They are not great for the first three to five feet of grain stored, but at the ten-foot depth-level, are considerable and must be allowed for in the bin construction.

A square or round bin of 100 square feet floor area and ten feet high will contain 20 tons of bulk wheat or barley. Considering only the walls of this bin, to build it of steel plate or expanded metal would cost over £100 in New Zealand. The cost if built of precast concrete staves, would be approximately £100; of concrete blocks, about the same; and of plywood approximately £37 complete with opening slide. This plywood has been borer-proofed, is resin bonded so that moisture does not weaken the plywood and if painted outside should have a long life. A 30-ton plywood round bin will be approximately £60 and kit sets of pre-drilled plywood sheets, cover strips, washers, bolts and instruction sheets will be available shortly.
The floor of all grain bins, in fact the whole floor of the granary, should be moisture proof and before the concrete floor is laid, a moisture-proof membrane of say tar or plastic sheeting must be provided. Even such items as disposal of rain-water from the roof are important. Bulk-grain storage and drying is essentially a process of fighting moisture and every care must be taken to prevent its re-entry.

The Bulk Grain-Store

The design and layout of the bulk-grain storage and drying plant is of the greatest importance, for the interest and depreciation on the capital outlay form the greatest proportion of grain-drying and storage costs—far greater than the small amount of electric power and labour necessary for the process. In a typical British costing, interest and depreciation on capital account for 82 per cent of the total cost of drying.

"Farm Mechanisation" of March 1959 carries a plan of a British plant suitable for 200 acres of grain and it is estimated to cost over £6,000 and in addition carries a Government grant of one-third on the building and bins of nearly £1,300. But this British farmer will sell his dried and stored grain for a premium of £5 per ton or approximately 2/6 per bushel!

In New Zealand, the farmer who bulks, dries and stores his wheat enjoys no premium compared with his neighbour who harvests his wheat into bags and stores it in a shed. For this reason, a deep study of plant lay-out, design and capital outlay is warranted. In New Zealand it would be advisable to design plants that are either multi-purpose (they can dry grain or hay and store grain or other crops), or that with the minimum of change-over, can be used for implement sheds or hay barns if the farmer goes out of grain growing. With this purpose in mind, three schemes are offered:

(1) The floor-vent system of grain drying.

One of the simplest means of storing bulk grain is to load it on to the concrete floor of a suitably weather-proofed shed. At 15 per cent moisture and protected from vermin, grain will store safely for up to 12 months. At depths up to three feet no undue wall pressures are exerted, but at the five to six feet depth, older buildings will require outside wall-butressing or internal cross-tying.

If the grain is out of condition, it can be dried by blowing air through a system of ducts laid on the floor and because the grain is not deep, resistance pressures and horse-power requirements for the fan are low.

However, in the filling, grains of many differing moisture levels are loaded into the shed and it is not possible under this system to treat them individually. Consequently, some grain is overdried and there is the possibility of damp pockets not being dried sufficiently. From the grain-drying angle, it is not an attractive proposition unless each line brought in is spread evenly over the whole floor area, a complicated business whether done mechanically or by hand labour. A shed 40 ft x 25 ft containing grain five feet deep would hold 100 tons.

(2) In-line arrangement of round bins.

In this system, an open-fronted lean-to implement shed 16 ft deep with a three-foot overhang in the front (facing the north-west) is built on a four-inch reinforced concrete floor. Stud height at the back is 14 ft and 16 ft in the front. The length of the shed accommodates four round bins each holding 30 tons with an area reserved for the fan and the pre-cleaner. An underground duct links at least two of the bins which have ventilated floors and can thus be used for drying if necessary. The other two are storage bins. A wet-grain pit is provided in the floor in front of the pre-cleaner and two
small pits between each pair of bins allow for emptying and loading into road-transport vehicles.

Where more than four bins are required, they may be erected in two parallel rows under a gable roof with an obvious saving in length of the top conveyor, but unless vehicle access is available all round the building for loading out purposes, a bottom central conveyor may be required.

(3) Multi-purpose arrangement of rectangular bins.

When it is known that other crops such as bulk potatoes are to be stored in the same building and there is the possibility that odd lines of lucerne hay may also be dried, the following scheme may be attractive.

The unit consists of say two storage bins and two arranged for drying—all erected under a lean-to roof, but the bins are square—12 ft x 12 ft x 10 ft high—and are built from concrete blocks with suitable reinforcing at the corners and in the walls, or from pre-stressed concrete slabs fitted into slotted concrete posts which are also pre-stressed. The fronts of the bins are arranged with slotted edges and a slotted centre-post is also provided. As filling proceeds the front is filled in with six-foot lengths of two-inch planking. In the bottom of the planked front wall, a slide is inserted to allow entry of an auger for loading out purposes. An extra bay is built for the pre-cleaner fan and should one go out of grain growing, removal of the interior walls leaves a building of permanent construction that will have many uses.

(4) The horseshoe arrangement.

The horseshoe arrangement of five rectangular bins of suitable size is a very attractive specialised unit for the grower who intends to store his grain for the maximum period and who has no other uses for the building. Five bins are built around a central wet-grain pit and a single elevator raises the grain to the roof where it gravitates into the pre-cleaner and thence into any of the five bins, all of which are within easy reach. Two or three of the back row of bins are easily convertible to drying bins by medium of an underground duct and the fan is housed in a suitable lean-to structure. For loading-out purposes, the five bins all discharge back into the wet-grain pit from which the grain is augered into the transport vehicle, or if sufficient head room is available, it is elevated to the roof and then slides via a shute out through the wall into the vehicle. (Dried grain will slide on a surface of 30 degrees, but if speed is required for higher output the slide should be at 35 degrees.)

Such an arrangement of bins is economical of floor area, roof area, elevating equipment, and of labour requirement.

Costing of the round bin arrangement

In the following estimate of costing, it was assumed that no suitable building existed. A prefabricated lean-to shed was purchased on the basis of delivered and erected on the farm. An outside contract was let to concrete the floor and build the underground ducts. Because of the variable distances involved, no provision was made for the supply of three-phase power on the wiring of the various units. No provision was made for labour of erection of the bins; it was assumed the farmer and his staff would do this. The pre-cleaner and conveyor costs are purely estimates.
Prefab. shed 60 ft x 16 ft with back and ends filled in and with front canopy £340
Four-inch reinforced concrete floor 960 sq. ft. at 3/- £144
Four 30-ton plywood bins at £60 £240
Two four-inch augers (17 ft) at £70 £140
One five-ton per hour pre-cleaner £250
One 15 ft chain and flight conveyor £50
Fan 4,500 c.f.m. at four-inch w.g. £100
7½ h.p. 3-phase electric motor £39
10 k.w. heater £25
Underground duct estimate £164
Plywood ventilated floor 300 sq. ft. £50

£1,418

This sum could be reduced if farm labour laid the concrete floor and assisted the carpenters.

Conclusions
1. Bulk-grain drying and storage is a practice in New Zealand. We have the necessary background of bulk harvesting and there is ample information from Wheat Research Institute and overseas grain-drying trials to guide us in the bulk drying and storage processes.
2. Our Canterbury climate is such that when drying is necessary, it is a simpler and more attractive project here than it is in Britain.
3. The construction of the bulk store and its processing equipment offer no difficulties from locally available material.
4. Bulk-grain harvesting and storage is a process that has much to offer in view of minimum labour required, ease and completeness. In the short run, it will appeal to those growing 100 acres of wheat or barley or 50 acres of both and I have no doubt in future years will be used on farms growing even smaller acreages of white crops. After viewing the attractiveness of bulk harvesting last season, I wonder why it is, that it is just becoming popular at this late date.

Acknowledgement
I wish to acknowledge the assistance of many technical experts in their respective fields who have assisted me in the preparation of this paper and in particular for their help in the field to thank those six bulk-harvesting farmers by whose foresight, perseverance and initiative this new process has been tried out and established in New Zealand.

(v) H. R. Evans, Department of Agriculture, Ashburton.

As we have not time to discuss all aspects of the economies of bulk harvesting, I would like to talk briefly about what appear to be the more important aspects. This must be sketchy and approximate as I have very little reliable data to go on at present.

The important aspects are: speed and flexibility; avoidance of losses; capital costs; running costs, labour requirements; the cost-size relationship.

A bulk-harvesting system has undoubted advantages of speed, flexibility, and convenience. The ability to be able to harvest for short periods at the maximum capacity of the header when weather conditions are tricky could be extremely valuable. Equally valuable is the fact that all grain harvested is under cover and safe from the
risks of flood and fire. These advantages cannot be assessed in terms of pounds, shillings and pence in a way which has a general meaning so each farmer must assess for himself their insurance value to him. This insurance aspect can be better examined after we have looked at the operating costs.

As no two systems in operation at present are alike we can take Mr Crosbie's example as a general case. He has described a plant capable of handling and storing 120 tons or 4,800 bushels. This is almost 100 acres at 50 bushels to the acre. You will probably find that you can cram an extra 200 bushels in somewhere so, for easy working, we will say it can handle 5,000 bushels.

The capital cost of this plant is estimated by Mr Crosbie at £1,400. This cost could vary by several hundred pounds according to how much work the farmer can do for himself. If he has a well-equipped workshop and is prepared to spend the time using it he can probably reduce the cost considerably. If he has to employ much outside labour however, or get outside workshops to make up much equipment the cost could be higher.

The running costs, with interest on capital at five per cent, a life of 20 years, and annual maintenance charges estimated at £50 are about £190. It should, however, be noted that over two-thirds of the cost of running this plant is due to the capital invested in it; depreciation and interest on the capital invested in equipment make up about 70 per cent of the cost of running this plant. The actual cash expenditure each year on maintenance and power should be very low. This appears to apply generally to any bulk harvesting system. In other words the maximum economies can be made by reducing the capital cost; provided, of course, that this does not reduce the life of the plant and thus increase the depreciation charge.

The savings are rather more difficult to assess. Some of them are obvious enough, such as sacks and twine. These are not needed under bulk harvesting and the savings would amount to about £70. Labour is a bit more difficult. A bulk-harvesting system can operate efficiently with two men, one driving the header and one driving the truck. Thus, if you normally have two men on the bagging platform, one can be dispensed with. The average rate of harvesting with a bagging machine, seems to be about 150 bushels an hour, so harvesting 5,000 bushels will take 33 hours, or about £20 in wages and meals for casual labour. Thus, if you normally use two men on the bagging platform you can save about £70 worth of sacks and twine and £20 in wages, or £90 altogether. If you have three men on the bagging platform you can dispense with two of them making a total saving of £110. So a system that costs £190 to run will save about £100. That is, interest, depreciation, and repairs and maintenance on the bulk plant are about £190 and the saving of sacks and labour is about £100. There is, therefore, a net cost of about £90 to offset against the convenience and insurance value of bulk harvesting. The price of 133 bushels of wheat is £90, so the question you must answer is, "Do you lose, on the average, something over 130 bushels of wheat, or 212 bushels of barley a year which could be saved by quicker harvesting, or by having the harvested crop under cover?" If you have lost 520 bushels of wheat every four years or 1,000 bushels every eight years then bulk harvesting should pay. This, of course, ignores the convenience factor. This you will have to assess for yourself as you know how much time and bad language you have spent in turning bags and anxiously watching the weather. It is worth some of the £90 a year to have no bags to turn.

One point about labour, though, is that if you normally do your harvesting with the permanent labour on the farm, then just taking one or two men off harvesting and putting them on to something else won't save you any money unless you put them on to productive
work which would not otherwise be done. Much farm work is fairly flexible, as far as time is concerned. What is not done now can probably be fitted in during a slack period later. The only saving could thus be £70 for sacks and twine plus the convenience and insurance against weather risks.

Finally, we have the relationship of cost to the size of the plant. It appears that the larger the acreage harvested the more profitable bulk harvesting becomes until, at somewhere around 10,000 bushels or 200 acres of grain the system should break even on actual operating costs. That is, the cash savings of bulk harvesting would then be roughly the same as the extra costs of operating it. Thus any insurance value of the system would be clear profit. This, however, is extremely approximate.

A couple of minor matters are, firstly, that the installation of bulk-harvesting equipment in any quantity ties a farm to cropping. Buying a header does this also but not in the same way. A header may be sold and the amount harvested each year vary but if one has an expensive plant, much of it with little sale value, capable of handling 5,000 bushels, how much grain does one grow? The second point is, that I have deliberately omitted any storage increment from the calculations as it applies equally to both bulk and bagged wheat.

I am afraid this paper is not as glowing with optimism as you might like it to be. The ideas put forward are very tentative and I may have been unduly cautious. I have, however, interpreted what few facts we have as accurately as I can. The key to bulk harvesting is undoubtedly in the capital cost and I feel that if, by the use of our ingenuity we can reduce the cost of the plant needed to handle the grain, we could very well bring operating costs down to a level where bulk harvesting is economic on quite small areas.

As matters stand at present, it appears that it is the larger farms which will be most interested in a full-scale bulk-harvesting system but there are many less costly variations such as the one described by Mr Kingsbury which could be usefully employed on smaller farms. This is, of course a step on the way to the complete bulk-harvesting system which I am sure we will see on a large proportion of our farms within the next ten years.

Q.: What is the minimum distance you would have to be from the railway siding to operate economically without doubling up your equipment?

Mr Mulholland: I should say, on an average, two and a half miles from the railway siding. If you went further, you would have to double up on the equipment at a terrific cost. I consider that if you were more than five miles away, you would have to go in for silos or some other form of farm storage.

Q.: Has Mr Crosbie investigated the storing of wheat loose on plastic sheets, and has he investigated the use of front-end loaders?

Mr Crosbie: As far as I know, there has been no bulk wheat stored on plastic sheets yet. As far as front-end loaders are concerned, I know one farmer who intends to handle his wheat on to transport vehicles by using a front-end loader.

Q.: Is it safe to store wheat at 15 per cent moisture on a dry concrete floor?

A.: Yes, if the floor is laid so as to prevent soil moisture rising. Let the concrete dry out properly before use.