The Proceedings of the Lincoln College Farmers’ Conference 1956

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The Proceedings
of the
Lincoln College
Farmers' Conference
1956
Men are never so likely to settle a question rightly as when they discuss it freely.

—Macaulay.
LINCOLN COLLEGE FARMERS’ CONFERENCE
1956

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Lincoln College,
Christchurch.
PROGRAMME

16, 17, 18 MAY, 1956

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The Chairman, Mr J. S. Hunt:

I wish to welcome you all here. I also would like to take this opportunity to welcome back our old friend Professor McCaskill, who does so much to make this Conference a success.

This Conference is growing in importance and should eventually be the greatest meeting of farmers in the South Island. The idea is to pass on to farmers the latest scientific knowledge of our business and make it possible to discuss here our problems, so we shall be able to produce more goods of a higher quality and if possible at a lower cost per unit. I quote a formula: “Because of our increasing population, the farmers, have to make an annual increase in the value of our exports to maintain the high level of overseas credits to enable this country to import goods to maintain a high standard of living.” This endeavour to increase production is a duty that has fallen upon us and we must not fail. We are now coming up against the problem of rising costs; this is a problem that is not peculiar to us alone. To enable us to do our job efficiently and well we cannot do better than study the papers that will be read to us at this Conference. In them you will find the answers to a number of problems that are worrying you today, and you will find the inspiration to go ahead with better efficiency in future.

I hope you will benefit from the papers and take back this information to your properties, neighbours and friends.

Address by Mr W. H. Gillespie, M.P.:

I count it a very great privilege to have been asked to officially open this year’s annual Conference and I want to take the opportunity first of all to thank those who have been responsible for inviting me to join you in what I consider a very important meeting. On behalf of the Board of Governors of this College and the staff I want first of all to extend a very warm welcome to each and every one of you and hope that the deliberations that take place here will not only be of value to yourselves but will be of value to a great many farmers throughout at least the South Island. I hope as you look round what is going on here at Lincoln that you will all be pleased with what you see, in particular the progress which has been made here in the last few years. I would say to you that it is the desire of those of us who are privileged in any way to serve here at the College and to serve the farming community through the College in any way, that we hope that in the years that lie ahead you will see very much more progress than what you see at the present time.

I think it would be fair on behalf of the Board for me to tell you that right at this moment plans are being prepared for a library which we hope will not only fill the needs of those who serve at the College, but will be of great benefit to the students who pass through the College. I hope that you will all agree with the name that has been chosen for the library; it will be known as the George Forbes Memorial Library. It will serve two particular purposes, first of all the College, and secondly the commemoration of the name of one of our best Prime Ministers. It is recognised by those who serve here also that there is the urgent need for a conference hall which will meet the needs of you people who gather here from time to time. I almost feel tempted to say to you that perhaps in the not so distant future we may have such a hall. Farmers from one end of the Island to an-
other might give thought to how they can help. I am certain that if you take away a conference such as this from the atmosphere of Lincoln it would lose much of its value. This annual conference, which is organised in collaboration with the farming community, is now recognised as a place where farmers throughout the South Island can get reports on practices which have been adopted with success and where some of the outstanding scientists review and report on the progress of research.

I now wish to give a very warm welcome on your behalf to this Conference to Mr. E. J. Fawcett, Director-General of the Department of Agriculture, who will deliver the main address, to Dr. McMeekan, and Dr. Wallace of Ruakura Animal Research Station, and also those farmers who are giving papers. Without their support and that of the members of the staff of this College this Conference would lose very much of its real value.

At present the College is served by an enthusiastic staff who are carrying on with an active research programme in many fields. You will be introduced to some of the work in papers given at this Conference. Some of the projects which are in progress here will lead to greater production through improved practices and there is considerable promise in others that we will improve the yield and quality of fat lambs and wool. But general research is not our only function here. As a teaching institution this College has trained many of the outstanding leaders in research and extension services in this country and overseas. It also works in close collaboration with the Extension Division of the Department of Agriculture to bring to the knowledge of farmers the proven practices resulting from investigation work. It is my firm belief that this College has, through research, application and demonstration, done more than any other one institution in the South Island at least, if not in New Zealand, to bring about increased primary production in its many fields.

I think one point of note is the increased primary production which has taken place on our lighter lands due to the introduction of sub clover and topdressing. It is pleasing to note that if Canterbury continues with its present rate of progress in stock-carrying capacity, it will be in a year from now the premier sheep province of New Zealand. I am hopeful that the past drought will not have too much influence on our stock figures. I believe, no matter how much we pay for research or how good that research is, or how well results of it are put across to the farming community, production can be further improved, and this will fall to the ingenuity and hard work of the farming community to obtain the worthwhile increase in primary production which is our desired goal.

We may say we have set ourselves a target, but I believe the farmers in 50 years' time will still be striving to increase our primary production. As we look at the present trend and its effect upon our economic position, some farmers and those connected with the farming industries are concerned. It looks as if the continued upward trend in prices for our primary produce has now passed its peak and we are passing through a levelling-out period which will bring some problems. The greatest problem is the need for wise farming practices to cater for the future. Although it is true to say that secondary industry in New Zealand plays a very important part and has occupied a very important place in our economy, the future prosperity in this fair land of ours lies in primary production. By the efforts of our farmers our future in this direction will be amply safeguarded.
Representing farming in a wide variety of fields, I believe you will approach your problems with vigour and enthusiasm and I can only wish you well, gentlemen, in your deliberations, but I do extend the hope that as leaders in the farming field you will be able to take back from this Conference to your fellow farmers many solved problems and probably some new ideas which will not only be of benefit to yourselves, but will be of benefit to farmers as a whole. In this you have my own personal goodwill, but I also bring to you in this regard the cordial goodwill of the Government.

Gentlemen, I again extend to you on behalf of the Board of Governors and the staff of this College the warmest welcome here, and wish you well with your deliberations. Mr President, I have much pleasure in declaring your annual conference officially open.
POPULATION—POTENTIAL PRODUCTION
AND MARKETING PROSPECTS

E. J. Fawcett, Director General of Agriculture.

During recent years I have on several occasions discussed the problems envisaged in the title of this paper—and had not expected to do so again. However, the Secretary has specifically asked me to give a lead to discussion on these subjects, and whilst necessarily indulging in some repetition, I believe them to be of sufficient importance to justify repetition.

**Population:**

I am not an expert on population trends and therefore must accept the estimates and forecasts made by the appropriate authority—namely, that our population will reach three millions by 1975 and even more astronomical figures are mentioned for the year 2000. An average accretion of 2½% per annum means say 50,000 new citizens each year—or a new Dunedin every two years. Fifty thousand more people to feed, house and clothe and approximately 20,000 potential additional labour units to be employed. It is of importance to consider how these labour units will be employed. Allowing for abnormal conditions round 1921 and 1936, it can be said that the labour force—owners and employees working on farms, has remained static—though some increase has taken place during recent years. The increases achieved in primary production have resulted from greater efficiency per unit of labour—not by employing more people. It is questionable whether this state of affairs can continue. I am of opinion that the average level of production per unit of labour now reached cannot be raised materially by further mechanisation. The stamina of human beings has limits. Therefore if production trends are maintained, more labour must be used—either full and part time—or more farm holdings must be created to permit of a greater farm population. In the meantime, however, the great proportion—almost the whole of the increased labour becoming available, is finding employment in servicing, manufacturing and ancillary channels.

In October, 1953, the percentage of our total labour force employed on farms was 17.5. In October, 1955, it was 17.1. Between these dates, farm labour increased by 1.7%; manufacturing by 5.9%; building and construction by 9.8%; distribution and finance by 6.1%; administration and professional by 4.0%. It is questionable how long this state of affairs can continue.

**Dependence on Exports:**

Nobody disputes the fact that, in the long run, ability to employ people in New Zealand at levels of remuneration designed to maintain a high standard of living, depends on our overseas earnings from the sale of products derived from sheep and cattle. Our overseas earnings have been great—terms of trade have been kept reasonably in balance—imports of consumer goods and raw materials have been heavy—wages and salaries in New Zealand have been good and steadily ris-
ing. Our increased population has been readily absorbed, much of it in unproductive channels. The problems lie ahead. Up to last year farm incomes were maintained at a level equal to or above incomes in other occupations. The recent trend in prices for primary products will almost surely reverse the position.

In the first instance at least farm earnings will drop more acutely than cost of goods and services used by farmers in production. The operation of guaranteed and support prices properly administered will maintain farm incomes at reasonable levels—but will not contribute to our exchange balances. The danger to our national economy becomes accentuated when we consider how dependent we are on the level of prices obtained for exports.

Between 1946 and 1955 the value of exports from New Zealand increased by £156 million, which was also 156 per cent. The volume of our exports rose by 22 per cent. In other words, had the prices for our products remained at the 1946 level, our overseas exchange earnings would have risen only by 22 per cent. Therefore, of our increased exchange earnings since 1946, £34.3 million, or 22 per cent., has been due to production efforts and £122.1 million, or 78 per cent. to the ability of United Kingdom and other consumers to pay more. This draws attention to our extreme vulnerability to price movements. It also accentuates the fact that we are consuming an undue proportion of our total production; a 27 per cent. increase in production in nine years, but only 22 per cent. increase in exports. Thus, volume of exports is barely keeping pace with population movement.

Expansion Since 1921:

Since 1921 volume of farm production has increased by about 160 per cent. What are the main features of our rural economy which surround this volume increase?

(1) Livestock carried has increased by about 85 per cent.

(2) Output in volume per unit of farm labour has increased by about 180 per cent.

(3) The total area occupied has not increased.

(4) The area in sown grass has increased by about 1½ million acres (about 10 per cent).

(5) The area devoted to fodder crops for stock has remained approximately static.

(6) The area sown to new grass each year (out of grass or after cultivation) has not materially increased.

(7) The number of holdings has increased from 84,100 to 92,400 and the average area per holding has decreased from 518 to 469.

(8) Utilisation of artificial fertilisers has increased by nearly 700 per cent.

(9) Breeding ewes have increased by about 115 per cent.

(10) Dairy cows have increased by about 126 per cent.

(11) Average production of butterfat per cow has increased by about 37 per cent.

(12) Average lambs ta\lled per 100 breeding ewes has increased from 83 per cent. to 97 per cent.

(13) Mechanisation of farms has proceeded rapidly: the number of electric motors has increased from 456 to more than 125,000; internal combustion engines from 15,700 to 29,000; agricultural tractors from 380 to 62,100; milking machines from 10,400 to more than 38,000; shearing plants from 5,300 to 21,000. In addition to the fore-
going, ancillary machines and labour-saving devices of all description have been added to what is now regarded as normal farm equipment.

The foregoing facts indicate that the increase in volume of production has been the result of:

(a) Provision of an increasing supply of better stock feed in the form of pasture herbage;
(b) Better utilisation of herbage available by controlled grazing and conservation;
(c) Improvement in potential producing capacity, particularly of ewes and dairy cows; and
(d) A remarkable increase in labour efficiency as a result of concentration by owners and employees on the foregoing, together with over-all mechanisation of farm operations.

Thus, we owe our ability to export an increasing volume of farm products to scientists, educationists, extension services, commercial interests, and, above all, to the remarkable capacity of the farming community to adapt goods and services to the advancement of our primary industries.

Requirements for Future:

The maintenance of production increases at a level which will equate volume of exports to population increases presents objectives in stock population of great magnitude. We must maintain annual increases in stock equivalent to 500,000 breeding ewes, 50,000 dairy cows, and 23,000 beef breed cows. Or to put it another way, we must by 1975 improve our farm lands by the equivalent of 6,000,000 acres having an average carrying capacity of one milking cow to each $\frac{1}{2}$ acres. The total capital cost of farm development and provision of ancillary services can well exceed £500 million.

New Zealand is capable of great expansion in primary industries. We can produce more dairy and meat products. We have the requisite knowledge on pasture establishment and utilisation. We know a great deal about pasture and stock management. Production increases essential to maintain an expanding economy can be achieved by an intensification of the proven practices which are being followed by progressive farmers today. We cannot convert the whole of our grassed country to 250 lb butterfat per acre farms, or their equivalent; but it is essential that as far as is practicable the methods adopted on such farms, with suitable variation, be spread to marginal dairy farms, to hill country which can be converted to fattening farms for sheep and cattle, and to harder country which is capable of assuming great importance as a reservoir for supply of store stock. The basic requirements to effect these advances are materials for subdivision, oversowing of pastures, and adequate applications of lime and fertilisers.

As much of this expansion must take place on hill country, an intensification in the study of suitable forms of fertiliser and types of transport for application is clearly indicated. Increases in stock population ensure that needed capital stock can be provided while current production is maintained.

It is obvious that there must be ever-increasing capital development in the provision of fencing material, aircraft and equipment, fertiliser plants and all the ancillary equipment and services associated with closer settlement and expanding industries.

It is certain that the existing labour force on farms will not be capable of an ever-expanding output per unit, but that more help in some form must be available.
It is likely that an intensification of stock on hill country will lead to radical changes in farming techniques, particularly in the use of mixed fertilisers and nitrogen, to produce bulk fodder required to supplement pasture grazing for the fattening of the additional stock envisaged.

The foregoing envisages that primary producers in New Zealand must be capable of maintaining production at lower prices, and therefore at lower unit production cost. If they are not able to secure adequate labour and management rewards for themselves, owner farmers will tend to economise on production expenditure, which will result in the long run in reduced efficiency and lowered output. Costs of production must be aligned with net returns.

How can unit costs be reduced? Primarily by an increase in production per unit of area farmed and per unit of labour used. The objective can be achieved only if labour becomes more efficient and if costs of production, labour and capital goods per unit of production can be reduced.

Items affecting costs and returns are of two types:
(a) Direct, which includes cost of labour, capital equipment, capitalisation of land and stock, costs of fertilisers, and general repair and maintenance; and
(b) Servicing costs, such as internal transport, processing, handling, freights and marketing.

Agriculture, which is to some extent in a favoured position, must expect to pay a toll to secure the general prosperity of the country. At the same time inflated capital values are not advantageous to primary industries. Goods and services essential to production should be made available without undue writing-up of costs resulting from tariffs, taxes, commissions and profits. Availability of adequate permanent and casual labour at economic cost is a pre-requisite to economic production.

Servicing costs in processing, transport, handling, freights and marketing impinge directly on the margin left to producers, and thus on our ability to sell on competitive markets.

To summarise my remarks to this point—
(a) We need an ever-expanding volume of production to cater for an increasing population's internal needs and to earn adequate overseas exchange.
(b) We have the land, stock and knowledge to produce the goods.
(c) If prices received overseas for our products tend to a lower level per unit of product, we must ensure that unit costs of production, processing and transport are synchronised.
(d) The internal economy of New Zealand should be moulded on the recognition of the importance of primary industries to the national economy; and, so far as is expedient in the over-all economy, resources of labour, capital and goods should be directed to the development and servicing of our main asset, the land of New Zealand, and to the production from that asset of purchasing power through the medium of sheep and cattle.

Assessment of Production Increases:

I have now reviewed some of the problems of production. It is pertinent to consider whether the production objectives essential to maintain balance between export volume and population growth will be likely of attainment. My field and economics staffs have worked
on this aspect of our economy—and the outlook is not as good as we could wish. Assuming that conditions essential to increases in production are operative, it has been estimated that in the next 20 years

- Dairy cows should increase by 24%.
- Beef cows and heifers by 37%.
- Breeding ewes by 45%.

These increases in breeding animals should result in an increase in exportable surplus of meat of 38%; of butter by 25%; cheese 15% and wool 55%. This South Island gathering of farmers will be more interested in the South Island potential.

It is estimated that of the New Zealand increase the South Island will account for 56% of the meat; and 56% of the wool. I will not discuss the South Island influence on exportable dairy products.

It appears questionable whether our production and export potentials are capable, on a strictly quantitative basis, of taking care of our increasing population even provided prices realised remain at approximately present levels, and terms of trade remain at par, or better. Our economic future depends in the first instance on the maintenance of spending power in the United Kingdom, and no inflation in prices of our imported commodities and raw materials.

**Market Prospects:**

What then, are the future prospects on our traditional markets?

For purposes of this discussion, we will look at wool and meat only. Since 1953-54 the average drop in New Zealand wool prices has been a little more than 4d. per pound, or over 7%. This does not sound very serious but reduces our overseas realisations by about £8 million. During the current season, our market for meat is showing perturbing trends. Chilled beef realisations have dropped by 40%—frozen beef by 20%—lamb by 4%, and wether mutton by 10%, or a total of about £5 to £6 million. We are constantly being asked why have these easing tendencies manifested themselves? Statistically they are hard to account for. In 1955 the total amount of meat of all types available to the United Kingdom was 2,693,000 tons. The average for the period 1933-38 was 2,632,000 tons. Pig meats are the only classification which has shown an appreciable increase. Stress has been placed on the recovery of the Argentine chilled beef trade, and undoubtedly this has affected the prices for both chilled and frozen beef. Prior to the war, Argentine exports of chilled beef to the United Kingdom amounted to nearly 350,000 tons per annum. It is estimated she may export 240,000 tons this calendar year. New Zealand reached 18,000 tons in 1938, and will exceed that figure in 1956. We are constantly hearing queries as to whether the chilled beef trade is worth while to New Zealand. The answer, I think, is that the United Kingdom housewife now has access to increasing quantities of fresh, and near fresh, meat which arrives on the market in varying quantities with no proper appreciation of current demand. She buys fresh or chilled beef to the best advantage, and as it is available at comparatively low prices, she scorns frozen beef. We must cater for the chilled beef market whether we like it or not. Prices we are now realising on the United Kingdom markets are not bad, but the trend is disturbing. It appears certain that we cannot continue pushing increased volume into a country of static population and living standards, without seriously prejudicing realisations.

The population of the United Kingdom is for all practical purposes static, and likely to remain so. Meat consumption per capita averaged 126 pounds between 1934-38—dropped to 91.4 in 1952 and
is now approximating the pre-war level, in fact will exceed it in 1956. Although per capita consumption in the United Kingdom is well below New Zealand levels (about 220 lbs.) this is no criterion by which to assess meat consumption potential in the United Kingdom, and any increase can be effected only by substitution for other products, on preference and price considerations. It is true that attempts are being made to exploit alternative markets for both dairy produce and meat—but it is necessarily a slow process. In the field of dairy products we are in constant danger from surpluses built up in the United States of America under their floor price policy. Meat is not affected in the same way, but it is becoming evident that it will be difficult to obtain access for New Zealand meat in any quantity—therefore expansion of outside meat markets must depend on slow infiltration into countries whose people are not traditionally meat eaters. The statement so often heard that half the world's population is underfed does not help the New Zealand farmer greatly, as the underfed, as a natural corollary, are under supplied with purchasing power—and this conditions the whole outlook of alternative markets.

As there has been only one complete year of free marketing and as, in fact, many markets, particularly in Europe, are still not free, it is, perhaps, too early to assess even in a very general way market potentialities. In the year 1954-55 New Zealand exported 387,000 tons of frozen and chilled meat of which 87 per cent. went to the United Kingdom. The balance of 13 per cent., approximately 52,000 tons, went to a wide variety of markets, the principal being Russia 9,800 tons (2.5 per cent.), Holland 9,200 tons (2.4 per cent.), Italy 7,100 tons (1.8 per cent.) and Canada 4,300 tons (1.1 per cent.). It is too early yet to say how much will go to other markets this year, but it is known that so far no shipments have been made to Russia. European countries which might otherwise take increased quantities, are busily engaged in developing their own agriculture. In any case possibilities are limited by lack of purchasing power combined with food habits in which meat plays a much less important part than it does in New Zealand or Australia.

It must be appreciated that heavy meat consumption occurs only in New Zealand and Australia, and to a lesser degree in the United States of America, Canada, and in certain of the South American States.

We are thus driven into recognition of the fact that the United Kingdom is, and will remain, our main market for meat, as of course it is for dairy produce. This does not mean that other markets are not important. Clearly the 52,000 tons sold mostly to European countries must make a difference to prices in the United Kingdom and no effort should be spared in an endeavour to develop European markets, an enterprise which will probably require the combined efforts of industry, Meat Board and Government. In 1954-55, the first year of free marketing, the United Kingdom took 124,800 tons of butter from total exports of 149,000 tons or 84 per cent. The other principal purchasers were Russia 10,374 tons or 7.0 per cent., Czechoslovakia 3,064 tons or 2.1 per cent., and Germany 4,486 tons or 3.0 per cent. It is significant that the only markets other than the United Kingdom to exceed 1,000 tons were Russia and Czechoslovakia, and still more significant that this year, due in certain instances to sales of American surpluses, sales to European countries have been restricted. Dependence on the United Kingdom market is even more marked with regard to cheese. Of total export of 96,000 tons, Britain took 91,071 or 95 per cent. The only other market to take more than 1,000 tons was Western Germany with 1,143 tons or 1.2 per cent.
There is not a great deal I can say about wool. Financially it is our most important export, but it has been sold on world markets since 1946. It is the one major export where the bulk of the supplies are not taken by the United Kingdom. Between 1950 and 1954 the United Kingdom took 45 per cent of total exports, the two other major purchasers being the United States of America and France, each with 14 per cent. Other reasonably substantial purchasers were Germany, Italy, Belgium and Canada. Because of its necessity as a raw material for the textile industry, countries purchase just as much wool as they require and at market prices. There is therefore nothing that can be done to develop alternative markets. I do not intend to discuss the question of synthetics and their effect on the wool market. Wool was uncertain enough long before any synthetic was invented. I would, however, go so far as to say that it seems almost certain that synthetics must exert a steadying effect on wool prices.

This brings me to the all-important question of the effect of market uncertainties on New Zealand's economic future. I have already indicated that in the past two years we have experienced a drop in wool prices, and this year's meat prices are down on those of last year. The butter market is most uncertain, and the bulk of the season's output is still to be sold. Even when allowance is made for production increases in all primary products, this year there may still be a decline in export earnings of 15 million pounds.

This highlights the whole question of future development. Should we encourage farmers to increase production? Should we continue development of new land? Should not our immigration policy be studied carefully in the light of future needs? Should not capital works programmes be scrutinised carefully with a view to eliminating the over-ambitious?

We cannot foresee the future and it is possible that some technical or other changes may alter the situation almost overnight, but the fact remains that unless we can find satisfactory markets for an ever-expanding volume of primary produce, New Zealand's future appears to be one of declining living standards. There may be some assistance from our developing forest industries, but it can at the best meet only a fraction of the needs of an expanding population which essentially must depend for its economic existence on two animals—the ewe and the cow.

**SUMMARY**

1. New Zealand's population is increasing by about 40,000 to 50,000 a year or over 2 per cent. per year. This means that farm production must increase by a similar rate, if terms of trade are at par or better—and by more, if the terms of trade move against us.

2. Forecasts suggest that this required rate will barely be reached, and some special effort will be necessary involving an all-round development policy covering such aspects of production as provision of requisites, labour, etc., provision of incentives, attention to port handling and transport facilities; in general the development of an economic climate congenial to farm production.

3. Indications are that the terms of trade may be moving against us, i.e. our export prices are falling while import costs are static, if not rising.

4. Alternative markets which may give us better terms of trade will not be easy to find, although no effort must be spared in this endeavour.
5. In the long run it will be largely a question of relative costs of production. Can the New Zealand farmer, given fair trading conditions, undersell his competitor? I think he can, provided costs can be held, or reduced. There is no way of reducing costs as effective as increased productivity per unit, of land, labour and capital.

DISCUSSION

Mr Hunt: During the last few years there has been a continual drive for increased production. With the extremely high prices of our products, the capital cost of that increased production by developing our land, fencing and fertilisers was carried mainly by surplus revenue and borrowing capital. During the last year there has still been the drive for increased production but there has also been a credit squeeze. These do not go hand in hand. Is it the policy of the Government that banks should put a greater squeeze on farmers? Farmers are compelled to reduce their overdrafts. How can we carry on increased production at the same time as we have less money to carry out that policy?

Mr Fawcett: I do not know how to answer this one. It is significant that for the last two years we have spent overseas considerably more than we have earned and it looks as though the same position will apply this calendar year. Even farmers cannot go on spending something they have not got and finally something has to be done to bring income and expenditure into balance. We have seen how that has been done or attempted to be done in Australia just recently when Mr Menzies put taxes up considerably to take some of the spending power out of the market. In England there are two methods: taxation and incentive saving. Credit squeezes are not confined to New Zealand. They will be employed more stringently in many countries where spending is higher than capacity to earn money to pay for it. I am afraid none of us like the idea of increasing taxation or restrictions in borrowing when we think we have just cause for it. I am afraid this thing will happen and must happen in our present economy.

Mr Scott, Ashburton: Could Mr Fawcett give an explanation of why the Argentine, out of the blue, has produced that colossal amount of chilled beef? Up until the time Peron was put out of power, the Argentine sent no chilled beef to England; then she suddenly started shipping chilled beef. Is she killing off capital stock animals or depriving her own people of their meat consumption?

Mr Fawcett: That is very difficult to answer because chilled beef has only come back into international trade during the last few years. In 1953 Argentine sent just on 3,000 tons of chilled beef to the United Kingdom, 10,500 tons in 1954, and 99,000 tons in 1955. It looks like 240,000 tons this year. New Zealand started reshipping chilled beef in 1952 with only 26 tons. We will ship over 20,000 tons this year. It is true, of course, that during the period before the chilled trade re-started, Argentine exported a considerable quantity of frozen beef. It looks as though there is definitely an encouragement given to the production of beef and secondly undoubtedly there has been a considerable drop in per capita consumption over the last two years.

Dr. McMeekan: My own guess, having met both producer and exporter in Argentine, is that they are not killing off capital stock. The probable story is simply one of transfer of frozen beef to chilled beef in a big hurry and a big reduction in local consumption with a view to getting an exportable surplus each year. The Argentinians are going hungry to enable this to be done.
Y.F.C. member: What is the Government doing for young farmers to enable them to assist in increasing production?

Mr Fawcett: There is no discrimination between young farmers and older farmers in regard to provision of capital for the purpose of land or capital stock. Therefore I would say the answer is that nothing particular is being done.

Mr Gillespie: You will be discussing ways and means of reducing costs and better methods of farming which naturally must bring about increased production. The aim of the Government right at this moment is increased production, and when the credit squeeze is mentioned, it is not the intention of the Government in any way to hold up worthwhile land development or worthwhile farming practices. The aim of the credit squeeze is to try and make most people find a little more of the ready cash to purchase articles which they want and put our house in order so far as overseas funds are concerned. It is not the desire of the Government to hold up land development and so far as young farmers are concerned, the Government is right now developing a great amount of land on which it hopes to settle young farmers. As we are now near the end of the settlement of servicemen the same conditions will apply to the young farmer. There is no need for me to say at this gathering that it will entail a great amount of borrowed money so far as the young farmers are concerned and they will have the goodwill of the Government in regard to that.

Mr Smith: The crux of Mr Fawcett's speech was, "We have to increase our production considerably in the next 25 to 30 years." The biggest difficulty is the drift of labour from the land. How can we channel more labour on to the land?

Mr Sim, Mid Canterbury: There appears to be a body of thoughtful men who believe that the population of Britain would be perhaps better reduced by some percentage and those people distributed round the Commonwealth. What would be the economic effect on New Zealand if we had more people here rather than export more to the United Kingdom?

Mr Fawcett: New Zealand has not raw materials other than those derived from stock, therefore the whole of our heavy industry development is dependent upon imported raw material. We have coal, wool, leather, and that is about all; therefore to bring another two, three or four million people into New Zealand quickly would not meet the difficulty which we are envisaging. We would only consume more of our commodities here and reduce buying power overseas; therefore we could not buy raw materials and consumer goods in quantities to maintain the standard of living required, or people employed. Australia has a great range of raw materials and therefore will be capable of expanding population very considerably in the next 20 years. We can hope that Australia will have a really big increase in population in the next 20 years, and must surely provide some outlet for New Zealand products. Unless her economy can rapidly increase primary production she must purchase from New Zealand.

Mr Thomson, Marlborough: Has any consideration been given to the development of the World Food Pool; the scheme put forward to solve the disorderly marketing of which Mr Fawcett complained in his speech and from which we suffer as a result of American and Argentine surpluses? Would it not be better if a scheme of orderly marketing of the world's food were to be put into operation as soon as possible?

Mr Fawcett: I was at international conferences on two occasions when this question was raised. It was pleasing at the conferences to
hear how all the delegates supported the idea. Unfortunately representa­tives of countries attending conferences did not always sway the governments of their particular countries when they went back and reported. It is somewhat understandable that governments of individual countries are not prepared to sink their own sovereignties and allow someone else to dispose of their surpluses. There does not appear to be much chance of such an organisation being put into operation.

**Dr Burns:** Would Mr Fawcett care to elaborate on his statement of possible alternative markets for New Zealand products? I refer to the possibility of developing markets at some expense in Europe and his brief reference to the low incomes of peoples in Asian countries. Could he comment on alternative markets and also whether different methods of processing and packeting of meat products may lead to increased consumption in present markets and possibly in alternative markets?

**Mr Fawcett:** A great proportion of the world's population are not eaters of meat in any quantities. To build up markets in countries which are not traditionally meat-eating countries is a difficult and a lengthy process. This must be done and it looks to me as though we will have to start in a small way in a great number of places in the East as well as in Europe. There are the problems of transport, storage, and the ability of the people to pay a price which we think is justified on our cost of production. That is why I say in the long run the extension of our markets in the East and elsewhere will probably have to be done at some cost to the producers. The pack­aging business I am sure will develop. Packaging of meat in quick­frozen form suits the better cuts. What will we do with the off cuts? If home consumers ate all poor parts that would be fine, but it is not practicable. It will be a slow process, but one or two companies are already tackling the problem.

**Mr McKenzie, Southland:** Is it not a fact that the Government would sooner have the farmers of the South Island growing small seeds, thus bringing more money per acre, than growing wheat for food? Would they sooner have clover and small seeds for overseas exchange rather than wheat for consumption?

**Mr Fawcett:** The Government would like you to do both; to export seed and save overseas exchange on wheat.

**Mr Oliver, Hororata:** It appears to me from your figures that apparently saturation has nearly been reached in the ability of the British people to consume our exportable goods. If this is the case is it a wise policy to spend public moneys on the development which is going on in the country with a view to increasing that exportable surplus?

**Mr Fawcett:** I asked these questions of you. Should we continue development? My advice to you is to go on producing.
THE WORK OF THE RUAKURA ANIMAL RESEARCH STATION

C. P. McMeekan, Superintendent.

I have been informed by the Director of this College that it is necessary for me first of all to explain where Ruakura is and what it is. It is situated on the small island to the north of the mainland here; it lies in the heart of the Waikato, the most intensive livestock producing area of the world. Ruakura proper is of approximately 1,000 acres of fairly average North Island dairy and fattening land. About 400 acres of it is consolidated peat of the type once very much despised and now just being appreciated for what it is really worth. About half the property is devoted to studies affecting the dairy industry; and on that half we carry approximately 750 head of dairy cattle and over the year about 1,000 pigs. The other half is devoted to problems of the sheep industry and normally we run 2,500 to 3,000 breeding ewes under fat lamb conditions, plus the normal number of beef cattle. In recent years we have increased considerably the beef cattle in order to get specific information on that side of the industry. In addition to Ruakura proper we have a hill-country station purchased some six years ago on the Raglan Range. It is a property of roughly 1,300 acres and we believe it is fairly typical of the six million acres odd of deteriorated hill country of the North Island. On that property we study of course only sheep and beef cattle problems and in effect parallel the jobs done on the low lands with similar studies carried out under high land conditions.

Now getting down to the job itself, I have decided to try to group some of our major interests there on the sheep and beef cattle side under three main headings; fat lamb studies, studies of lambing percentage and studies of cattle production. Finally, I will finish up with a few odd things which I have been told today some of you are interested in, like hogget ill-thrift and facial eczema.

Our job is to try to study from the point of view of making the job more effective what is New Zealand's basic industrial problem, the problem of converting grass to milk, meat and wool. To a very large degree that simply means the job of putting animal production on to a factual basis. You all know the number of ideas you and others have inherited from your fathers and associates that you have had to modify or abandon in the light of newer knowledge. Accordingly, to a large degree at Ruakura, we have been given the job of finding out which factors are important and which are not, so that we have a clearer idea of the things that are important in relation to efficiency in animal production.

Studies in Fat Lamb Production

In that particular field over the last ten years or so we have collected data along ten main lines. These I will run over very quickly. First of all, as a result of the interest of the farmers of the North Island, in particular, in the best class of ewe for fat-lamb production, we have spent a great deal of time trying to see whether there was any important relationship between the conformation of the
breeding ewe and the quality of her fat-lamb product. Without going into any details at all, I think it is fair to say that all those studies, which covered many thousands of ewes and several years, showed that even gross differences in the conformation of Romney breeding ewes had no important or even measurable effect upon the quality of, or grading if you like, of the fat lambs produced. Farmers often argue that the quality of the wool carried by the breeding ewe affects the quality of the lamb. This is one of the alleged reasons the North Islander has believed was responsible for the high reputation of the so-called “Canterbury lamb” coming from fine-wool ewes. We made quite an intensive study of the relationship between the type of wool produced by the ewe and meat quality of the lamb, again with completely negative results. We naturally then turned our attention to the ram and followed up studies which I began here at Lincoln, and attempted to measure, under North Island conditions, the relative merits of a large number of different breeds of fat-lamb sires from the point of view of the rate of growth and carcase quality of their progeny. I think we compared the Southdown, Dorset Horn, English Leicester, Border Leicester, Cheviot, Romney and the Suffolk, as breeds available to be used for fat-lamb production. The general idea was to enable us to answer farmers specifically rather than in general terms when we received, as we were doing over those years, many inquiries as to the particular attributes of a Suffolk, a Southdown, a Border Leicester and so on. This sort of information is not new to you; you are familiar with it because it has come to you also from Lincoln of recent years, and, from your own experience, since the South Island has always been an area where more than the Southdown breed has been used for fat-lamb production. The results are as one would have predicted, with the Southdown pre-eminent from a quality point of view (if one accepts as a standard of quality current and past grading system under which our meat is graded for export); but of course the poorest of the ram breeds from the point of view of weight of lamb per ewe or per acre under similar carrying capacity conditions. The bigger breeds like the Suffolk and Border were at the top of the tree in terms of weight of lamb produced and at bottom in terms of quality, with straight Romney itself and intermediate breeds, in intermediate positions.

This class of work along with similar studies conducted here and at Massey lets us know accurately what breeds of ram we have to use in order to produce carcases of a particular type. This information might become very useful during the next ten years should the trends evident over this last year of free marketing continue; trends which, as you know, have resulted in our second-grade lambs bringing more per pound on the London market than our Down cross, or so-called superior grades. Reasons are many and varied and time will tell whether they are going to be permanent. If they are, obviously a change of ram breed will be necessary to provide a lamb carrying less fat, similar to your Canterbury lamb rather than the North Island Down-cross.

By this time Lincoln here had interested itself also in the ram quality side when McLean and his associates studied the difference between very good type and poor type Southdown Rams, and Massey on the other hand studied the difference between different strains of rams on a progeny test basis. If one puts all this information together I believe it is possible today to give a young farmer sound advice on both ewe and ram selection insofar as fat-lamb production is concerned.

We had a look, too, as many others have done, at the castration problem, not only from the most common angle of castration methods, but also from the point of view of the effect of castration itself. This
was a job done under war-time conditions, but the lesson should not be lost sight of insofar as the future is concerned. We found, of course, that the ram lamb produced a heavier carcase, a leaner carcase and a carcase that would command a higher price today than the castrated wether lamb under existing market trend conditions. The gain from not castrating varied in different years from two to four pounds per lamb. It is not a method which appeals to the New Zealand Meat Board for all sorts of reasons, but it is a method which results in the Southdown-Romney lamb being a leaner type lamb, a meatier lamb than by the methods we use at the present time. I am not advocating this as a technique; I am merely mentioning it to indicate the way we have been trying to pile up factual information about fat lamb production.

On the nutrition side Dr Wallace has been concerned with studying the effects of different levels of nutrition, at various stages of the reproductive cycle of the ewe, on the number, survival rate and growth of the progeny. Lincoln has been engaged in similar studies, and putting the two lots together today I believe it is possible to propound, for a sheep farmer in almost any part of New Zealand, an enlightened feeding programme for a fat-lamb producing flock.

Meat Production per Acre

A good deal has been said in the past about the relative merits of set stocking and rotational grazing of ewes and lambs. Very little, if any, experimental data had ever been obtained on this quite basic subject until some of the Ruakura people decided to have a look at it. Their conclusions may be of general interest. First of all that set stocking of ewes and lambs (after lambing I am talking about now), is superior to rotational grazing at low carrying-capacity rates, that is rates under North Island conditions of three to four ewes per acre. There is no difference between the two systems under intermediate stocking-rates (round about five to six ewes), but rotational grazing was superior to set stocking under high stocking-rate conditions of seven ewes and upwards per acre.

Latterly one of our major interests has been the study of stocking rate and stocking ratios in the production of meat and wool per acre. We have had an experimental design on a farming basis whereby we have been able to compare four ewes per acre plus cattle wintered; six ewes per acre plus cattle bought in the spring and fattened; eight ewes per acre and no cattle; all breeding cows rearing chillers only with no sheep; all heavy steers producing fat cattle only; and at the present moment all light steers and all heifers. We will eventually have a fairly complete range from all sheep to all cattle; different ratios of sheep to cattle, and different types of cattle. Our objective has been to see if there is any difference in the efficiency with which grass is converted to meat, with the different types and ratios of stocking. So far as is practicable under farming conditions, all feed that is grown is actually utilised. Dealing at the moment only with the fat-lamb side of this job, there are two major lessons which I believe are of importance.

First of all there was no difference between four, six and eight ewes per acre in the total amount of saleable meat produced per acre over the four years under which these three systems were compared. There was no difference in the total amount of meat produced per acre. There was naturally a big difference in the amount of lamb meat produced, with least under the four and most under the eight; but the extra beef, the meat produced from the cattle run in conjunction with the lower ewe stocking rate farms, counter-balanced the fall in lamb-meat production. The second point, of course, and one which is very important to all of us who are farming, is that from
an economic point of view the most profitable farm was the eight per acre ewe farm, where the large amount of fat-lamb high-priced meat produced, plus the large amount of wool produced, resulted in a higher net profit than did either of the other two systems which were handicapped by the lower price for beef meat. More important, however, than either of these two factors, and with special reference to the statements of the Director-General this morning, is the fact that these studies have, I believe, set a target for meat producers strictly comparable and just as valuable as the target set many many years ago by Mr Fawcett himself for the New Zealand dairy farmer.

About 30 years ago Mr Fawcett, studying the dairy farm production, suggested that a reasonably efficient farmer should be able to produce 200 lb butterfat per acre. From these studies, which I would repeat have been carried out on no better than average quality fattening land, I believe that a target of 250 lb of dressed meat per acre is well within the capacity of the average North Island fattening farmer. Just how that is going to plan out down here is something I would like to hear some discussion on later.

As a matter of interest, too, another angle arising from these stocking-rate studies is the vital statistics data derived therefrom. I was inflicted with all kinds of dire predictions about worm parasites in the heavily stocked ewe farm. In actual fact there was no essential difference in the health of the ewes or the lambs under either the four, six or eight per acre stocking rates for the whole of the period of the experiment. Even in terms of internal parasites (and here our data is based on an actual count of the worms in the gut contents of every lamb at slaughter) there were no more worms per lamb under eight ewes plus lambs, than under four ewes plus lambs per acre.

Fertility Investigations in Sheep

We have been interested in the fertility of sheep now for quite a number of years, with unfortunately not as spectacular results as one might have hoped. We have felt that no greater contribution could be made to the New Zealand sheep industry than to increase effectively the lambing percentage on the average farm by 10 to 20 per cent.

—I know that studies of this type are of no interest whatsoever to those fortunate enough to farm in Southland, where for some reason lambing percentages appear to be higher than anywhere else in the country, and certainly high enough for all practical purposes. The argument is that if we can lift the lambing percentage of particularly the Romney ewe, to something like the Southland level, a very real increase in efficiency in this job of converting grass to meat would be achieved. The problem has been approached in a number of ways.

First of all on the breeding side.—Along with Mr Stevens here I started to get interested in the possibility of improving basic fertility through breeding when I was at Lincoln. Mr Stevens has succeeded in building up a Romney flock which does have a very high lambing percentage and some day I hope he will tell farmers how he has actually done it. Under carefully controlled conditions at Ruakura, where we have run three flocks, one selected for high lambing percentage, one selected with no reference whatsoever to lambing percentage, and one selected for a low lambing percentage, we are finding it extremely difficult to get very much difference between those three flocks. There is a difference, but it is still small, only of the order of about 7 per cent. But it is of the order that one might expect from the theoretical studies on the heritability of fertility in sheep, which is a very low figure indeed. In other words, it does look, both from the point of view of theory and our practical experience at Ruakura,
to do it through breeding is likely to be a slow process. Obviously a very much more rapid attack on the breeding side is to try cross breeding. Massey has done this with its Cheviot-Romney cross developed for the harder North Island hills, and almost the whole of the superiority of the Cheviot-Romney cross in the north can be attributed to the higher lambing percentages obtained from the animals resulting. The Cheviot, however, is very little use over most of the country and accordingly we have been testing the possibility of injecting a bit of fertility into the Romney by using the Border Leicester. So far, under hill-country conditions, the use of the Border has actually stepped up the effective lambing percentage by 15 to 20 per cent.

On this fertility side we have also been interested in the ram. I do not propose to say much about this because Dr McLean will be handling this phase later; sufficient to say that as an extension of the testicle palpation system for eliminating the really bad rams from flocks and getting at increased lambing percentages by seeing that only fertile rams are used, our staff have developed a modification of the Australian system of collecting semen using an electrical apparatus. This is an outfit which is not expensive to make or to buy and which could be used by every veterinarian in the field without special facilities, so that semen samples and subsequent laboratory examinations could become a practical possibility and a better guide than the system we have to use at the moment under field conditions for testing our rams.

We have been interested, too, in the nutrition in relation to lambing percentage. Everybody who has ever had anything to do with sheep has heard of, or knows something of, flushing and its effect upon stimulating ovulation rate and the number of lambs born. Over a period of four years, Dr Wallace, who is specially interested in reproduction, attempted to get some factual evidence on this practice to see whether it really worked, to see what was really required and what flushing really meant, and to see what really happened when ewes were flushed in various ways. As a result of these studies, rather than just give farmers the advice to say flush your ewes and you will improve your lambing percentage, I think it is possible to give more specific recipes today. In particular Ruakura studies show that flushing, unless it is commenced at least three weeks before the ram goes out, has virtually no effect; that it needs to be continued for three weeks after the ram goes out; and that it has no effect after that time. That in essence is our main conclusion insofar as flushing is concerned. It must be remembered that flushing has certain disadvantages. It results in a greater spread of lambing and slightly more dry ewes, even though it does result in a 10-15 per cent. more effective overall lambing percentage.

We have been interested also in attacking the problem of the lambing percentage from the negative direction, from the point of view of ewe sterility. The job is a pretty slow one because, as in dairy cattle, our knowledge of the causes of infertility in sheep is still pretty rudimentary. But it is of interest at least to place on record the data we have at the moment which suggest that in sheep, as in breeding dairy cows, most of the dry ewe problem is due to what the dairyman calls temporary infertility and is not sterility at all. We have based that statement on the fact that if we take ewes who have been dry for two successive seasons and in the third year give them an opportunity for mating, in approximately 70 per cent of the cases they conceived. This is almost precisely the same figure we got from dairy cattle; about 70 per cent of the cows culled in any one year as sterile, if not killed but mated will get in calf. So that the problem has got to be tackled from the point of view of finding out,
not the cause of sterility, but the cause of this temporary inability
for the female to conceive. This is a much tougher problem than
trying to find out the cause of a straight-out sterility situation. Of
the remaining 30 per cent of ewes we have examined over the years,
we have been able to find a reason, for what it is worth, for the cause
of sterility. About 17 per cent of them have occluded fallopian tubes,
so that the eggs cannot pass from the ovary to the uterus or the
sperm cannot pass up through the tubes to fertilise the eggs. In
about nine per cent of the cases the ewes have conceived by the
embryos have died. In about three per cent they have infantile
reproductive tracts; about one per cent have mummified foetuses
(that is, the lambs that have died and not passed out); and in one
per cent of them only we have not been able to put a name to the
cause. These figures are not of practical use, but are mentioned here
merely to indicate the distance we have gone. In examining large
numbers of dry ewes sent to the works each year it is of interest to
note that of those that are actually empty, 30 per cent of them have
blocked fallopian tubes. The importance of a study of this type is
that immediately to the pathologist and reproduction physiologist
there has been a problem pin-pointed. We should obviously now turn
our attention to finding out why these tubes block and from that we
might get something of use to you people in due course.

Another angle on the infertility side involved the two-tooth situa-
tion. Two-tooths are notoriously bad breeders in the North Island.
How bad they are down here I do not know. If one believes Lincoln
College staff all their two-tooths get in lamb anyway and I suppose all
yours do too, so I am merely wasting my breath. But under North
Island conditions if you get 70 per cent lambing from Romney two-
tooths you are a pretty good sort of farmer; at least a pretty lucky
one. So that in particular we have been interested in the reasons for
the lower lambing percentage in two-tooth ewes and the special prob-
lems associated therewith. The only positive contribution made so
far is that a high proportion of those ewes which do not get in
lamb appear to have infantile reproductive tracts, tracts such that
it is rather difficult for the ram to mate. It does look as if mere
mechanical enlargement of the aperture will materially assist the ram
in performing his natural function and improve lambing percentages
accordingly. This is, however, something that has not yet been
accurately enough tested to recommend, but I would suggest that
farmers who are experiencing trouble with two-tooths might with
benefit have the ewes examined to see how easy it is for the ram to
mate.

Beef Cattle Production

Turning now to a few cattle studies, here we have been interested
in trying to measure, or get basic data on beef cattle production from
which to make a start. It is amazing how little information exists in
New Zealand about the growth performance of beef cattle, for
example, yet such information is quite necessary in order to get to
grips with the many problems which are obviously associated with this
phase of production. Even a simple ignorant South American peon
knows how many kilos live weight the cattle under his charge have
put on in a month because he regularly weighs them to that end.
On the growth-rate performance the farmer owner assesses the effici-
cy not only of his men but also of the cattle, pasture and general
management methods. We are just starting to get that sort of
information under hill-country and fattening conditions, and at the
moment it is not worthwhile saying much about them except to give
as a guide the following figures as representing the kind of perform-
ance which one might expect under hill-country and fattening condi-
tions with our present cattle.
On fattening farms in the North Island the cattle should grow at an average rate of 1½ lb live weight per day from weaning onwards. If you work that out you will find they make chillers at the right age of the right weight in the right time; in practice they do grow from anything from half a pound to that level. The average live-weight gain over the same period from birth to two years, under hill-country conditions is a little under half a pound in the North Island, and that is the reason for the poor quality of our freezer cattle and many of our chillers as well. A second interesting point, of very great importance, if cattle are to become a factor in either the South or North Island, is that one-year-old cattle put on as much total live weight in 12 months as two-year or three-year-old cattle—approximately 450 to 500 lb. If that be true it means the younger animal is a much more efficient converter than the older and heavier one since they both make the same total gain, but the big one is needing a lot more feed to keep him alive than the small one. It is for that reason we are getting a higher output of beef per acre from light-weight cattle than from heavy-weight cattle.

The age at first breeding has also been an angle which interested us and, particularly on good country; we have wondered whether it is really necessary to calve down beef cows for the first time at three years of age. Cattle production is inefficient enough in my personal judgment without loading it with an extra year's maintenance cost on the part of the mother by keeping her to three years if she can be calved down at two. Accordingly we have compared Aberdeen Angus cows calving at two and calving at three, and find that, providing we can get an Aberdeen heifer as big as the average Jersey at two years of age, she becomes a very efficient mother; there is no loss in efficiency so far as her calf relative to calves from older cows are concerned, and she produces one more calf in her lifetime and starts production at an earlier age. Provided the animals are mated so as to calve at about 700 lb live weight at two years of age, the results from early calving are just as good from the point of view of calves as results from later calving, with the over-all gains in efficiency already mentioned. We wondered whether the cattle producer could not learn something from the dairyman. He has been weaning his dairy calves earlier and earlier over the years until we have got to the almost ridiculous situation when current Ruakura recommendations to the dairy farmer for calf rearing are to feed calves once a day for eight weeks and wean, against the old system of twice a day for 16 weeks as a very minimum.

Now what happens to the beef animal under similar conditions? Early weaning studies with beef cows have shown that it is perfectly practicable to wean at four months of age; the animals are only a few pounds lighter than those weaned at the normal eight or nine months' stage, and by the time both lots are a year old they are indistinguishable in type and are of the same live weight. In other words early weaning is a practical possibility in beef cattle production from a farming point of view, particularly in the use of breeding cows to develop hill country, it has many advantages it is a system worthy of trial by farmers interested in the use of breeding cows.

Of recent years we have been specially interested, too, in the possibility of making some use of the dairy industry to contribute to beef production. It is no news to Canterbury people that a dairy cow makes good beef, but since most North Islanders live on Jersey cows the very idea that the Jersey cow might be used as an incubator for producing beef-type calves is so foreign that these animals at Ruakura are universally known as “McMeekan's mongrels.” Obviously a tremendous potential for beef does exist in the use of those dairy
cows in the industry, the calves of which are not kept for dairy herd-replacement purposes but which are normally slaughtered at three days or seven days, officially as bobbies. One of the big overhead costs in beef production (and one of the main reasons why it is not economical in this country) is the cost of keeping two mothers for each steer, then the possibility of producing a lower quality but still saleable cross-bred beef article is obviously worth having a look at. In Great Britain today it is estimated that, as a result of the use of beef bulls on dairy cows through artificial breeding, the day is not far distant when approximately one-third of the total dairy cattle of Great Britain, or in total roughly of about 1,100,000 dairy cows will be mated to produce cross-bred beef in this way. They will of course be mostly Shorthorn and Friesian cows and not Jerseys, so the beef might be better than we would expect. At the special request of your Meat Board, and in particular the chairman who is especially interested in this phase, we have over the last few years been mating Aberdeens with Jerseys and studying results. We have been able to show that they produce quite a saleable, marketable vealer carcass in 18 weeks and it is a profitable way for the dairyman to get rid of his skimmed milk as an alternative to pigs. In addition we have carried them on to the chiller stage and exported them to Great Britain.

I would like to summarise the report received a few days ago on a shipment of these mongrel animals. It is a report from the people set up by the Meat Board to examine the carcasses. The quarters landed in very nice condition and rather better than the ordinary beef out of the same locker. The carrying temperatures were 29°F with only eight per cent gas; there was a slight trace of gas discoloration and this was limited to small patches on the hinds. On the fores there was a slight over-all shading. Some of the surface, particularly round aitchbone and neck had darkened. Apart from these slight defects the external appearance of the beef was good, the colour bright and fresh on the stands, and 48 hours later showed a strong resemblance to home killed beef, the fat having retained full ripeness without any oxidation. The rumps and loins looked better than the buttocks. When cut the appearance was very pleasing with a complete absence of ice crystals and excess moisture. Quality proved to be much better than our knowledge of cross breeding had led us to expect; weights were ideal for the average retailer but rather light for Lyons’ requirements. Quarters were full-fleshed with good texture of meat. The buttocks were long and not well filled; the beef was not wasteful except that some hinds carried heavy kidney knobs. The particular yellowness characteristic of the Jersey which is disliked by the trade was absent. The only point of doubt as to whether these quarters, in the ordinary run, would have been graded out as chillers was in respect of the poor conformation of the buttocks; in all other respects they would easily qualify. I am not suggesting that you import North Island Jerseys to produce beef in the South Island, but do suggest that you do not necessarily believe stories that, because a lot of South Island cattle are derived from dairy mothers, you cannot produce good beef. I believe you can.

Problems of Animal Health

Now I will skip over cattle production per acre and will go on to at least four items on the health side. We are still getting enquiries from the South Island about the disease of sheep which is called Southdown photosensitivity; it is a disease which we first picked up from South Island stud Southdowns and is of course an inherited one. It has nothing whatsoever to do with facial eczema although sheep have similar lesions on the face. It occurs in lambs once they start to eat grass in the spring and is due to a congenitally defective liver. Hancock at Ruakura has worked out its mode of inheritance; he has
shown that it is very simply inherited, and has indicated ways and means whereby, if it does occur in a stud, it can be slowly eliminated. Similarly the hydrops foetus situation continues to bother us from South Island breeders. This is a condition where the lamb becomes so big and dropical that it is physically impossible for the mother to give birth to it and she dies in consequence. The lamb weighs round about 30 lb at normal term instead of its usual 8 to 12 lb. This again is an inherited condition. It exists in the Romney breed and so far its major home seems to be Southland. Both conditions can be bred out and most farmers who have struck the trouble know now how to handle it.

We have been specially concerned with hogget ill-thrift at Ruakura. This is a hardy old annual as I remember the Kirwee Experimental Farm was established to study the lamb mortality of Canterbury in 1938 when the Canterbury farmers lost about one million lambs. A great deal of work was done, but as I remember, no ill-thrift occurred during the ten years’ work under progress. This points to one difficulty which research workers have, that is to study a problem which is not with you. It was a fact that at Kirwee no trouble was experienced using standard procedures in rearing quite good hoggets. Under North Island conditions, however, you can guarantee to get hogget ill-thrift anywhere and every year. Certainly we, in the research side, still do not know a great deal about it, although we have put in six years of concentrated effort following up every idea that any farmer suggested that appeared to be worthwhile and every idea of our own. There are a few observations I would like to make about the results we have obtained. First, we are quite convinced as a result of considerable experimental evidence that there is no true relationship between internal parasites and the thrift of hoggets, that parasites are not a primary cause of ill-thrift in sheep. If parasites have any affect at all they are secondary and merely become important because something else has previously knocked the sheep about to the stage where they can become a major factor. We believe that is the case because we have produced all the symptoms typical of hogget ill-thrift in the complete absence of parasites. We have reared parasite-free lambs by taking them from their mothers at birth, rearing them inside and then running them on pastures completely free from sheep parasites, pastures from which they got no parasites, and pastures on which they became completely unthrifty at the normal time, later March, April, May, when the flush of grass occurs in most part of New Zealand. The only exception to that attitude on the parasite side is the Haemonchus or stomach worm, which, under special circumstances, could become a primary cause of the trouble. But it is readily diagnosed by most farmers and any veterinarian knows it; it is completely controllable with drenches and it may or may not be a factor in thrifty or unthrifty hoggets. We believe that most drenching in sheep is a waste of time and money. Thrift is nutritional and will be solved only that way. One certain way to produce ill-thrift under North Island conditions is to put them on to short feed. One certain way of producing healthy hoggets is to put them on cow feed. Providing long feed, not short feed, is the only practical way we can avoid the trouble. The problem seems to be one of nutrition; hoggets are unthrifty because they do not eat; why they do not eat we do not know. The primary cause of ill-thrift in hoggets on hill country or flat is the decision on the part of the sheep itself not to eat and if they are made to eat this will produce automatic recovery.

Facial eczema got to Marlborough and Nelson last year and this year. Since some of you did come up against it, we would like to say just one or two words about it, if only to remove a few misconceptions and indicate that while we still have a long way to go we still
know quite a lot about it. Facial eczema is a disease of the liver and not of the face. It is caused by a toxin present in the kind of grass which grows under particular weather conditions in the early autumn months. This toxin makes it impossible for the liver to do its normal job of excreting phylloerythrin, which is a breakdown product of chlorophyll, the green colouring matter of the grass. This phylloerythrin piles up in the blood system, it cannot be got rid of, and it makes the exposed areas of skin very sensitive indeed to sunburn. The scabs and sores on the face of sheep and on the white patches on cows are simply a sunburn effect arising from a defective liver. The second point is that not all sheep show the outward lesions; if you get one photosensitive animal (that is a clinical case with scabs) in a flock of sheep you can reckon on having from 20 to 40 with the disease in the same flock. You do not need to have many sheep affected visibly to know you have 100 per cent with damaged livers. The third point is that the liver damage is completely incurable. I mention this because if ever it does come down here it might save a lot of time trying out a hundred and one things which the farmers in the North Island have tried out for many years. It is incurable because it is a progressive disease, a disease where the bile ducts have actually been destroyed. We do know, however, that it is preventable. Prevention is quite simple in theory, difficult in practice. If the disease is caused by a toxin present in the grass, then if the animals are prevented from eating any grass at all they obviously cannot get facial eczema. As long as one knows when the grass is dangerous and when it is safe it is quite easy to devise techniques for protecting the flock or herd. Therein lies the rub. At the moment we have to guess as to when pastures are dangerous and when they are safe. But for North Island farmers at least we have a service which is working out fairly well and there really is no excuse today for a farmer suffering any substantial losses from facial eczema if he will accept our ideas about it, accept our warnings and practice our advice.

Of that I am perfectly certain because I have been able to protect the flocks at Ruakura in six outbreaks which have occurred in the Waikato since I have been there. With that, Mr Chairman, I will allow you to throw me to the wolves.

DISCUSSION

Mr Menzies, Banks Peninsula: What was the effect on the pastures of the various methods of stocking?

Dr McMeekan: The worst pastures after four years were the lightly stocked ones: four to the acre. The best were the six and eight with very little difference between them. In certain patches on the drier soil types, at eight per acre, there was some invasion of weeds of one kind and another. The eight ewes per acre have not yet been continued long enough to answer all the pasture questions which are obviously interesting, but we are not at all concerned in carrying on on that farm with eight ewes per acre.

Mr Scott, Ashburton: (1) In rotational grazing what number of sheep was included in a mob? (2) What have you to say about the claim from America that they have controlled bloat by the use of penicillin?

Dr McMeekan: (1) The experimental mobs totalled 150 ewes. (2) Most bloat in America seems to be different from our bloat. We do not know about the effects of penicillin on our form of bloat.

Mr Turton, Ashburton: What are your observations so far as lambing percentages are concerned? Would you consider a mild or warm climate would have anything to do with lambing percentage?
Dr McMeekan: Sheep are essentially seasonal breeders and are
affected by ratios of day and night. I have been trying for some
years to organise experiment with Southland whereby I exchange
some of my flock with somebody's there. I will send half of my flock
to Southland and get half of their's a month before tupping. My
guess would be that the Ruakura ewes in Southland would be as good
as the ewes in Southland, and the Southland ewes in Ruakura would
be as bad as the ewes at Ruakura. The closer you go towards the
Pole the better the breed performance. I hope this experiment, if
carried out, works out as I expect.

Mr Palmer, Southland: The average lambing percentage for my
district is 120. It is not big enough. We would be very interested
in breeding Border Leicester with Romney; our worry would be the
decrease in wool production. Could you tell us how the extra lambing
percentage would offset the decrease in wool production with the
resulting cross of Romney/Border Leicester?

Dr McMeekan: Over the last five years at Ruakura the cross-bred
ewes gave a lb less wool per ewe than pure Romneys. The cross-bred
 ewes and the Romneys were run together from birth.

Mr Earl, Waikari: Do they give supplementary feed when stock­
ing eight ewes per acre during the winter months?

Dr McMeekan: No, it is entirely a grass job.

Mr Quigley, Waipara: Have you found from experiments any
relation between lambing percentage and the amount of wool the
Romney has on legs and face?

Dr McMeekan: Dr Coop will be dealing with the problem of face
cover in sheep in relation to efficiency. Open-faced sheep of the
Romney and Corriedale breeds have a higher lambing percentage. In
our cross breeding work at Ruakura we do not propose to go on using
the Border after the first cross. We are trying to get genes for high
fertility into our flocks and then go back to typical Romney flocks
for the hill country.

A speaker: Have you found in castrating experiments any marked
inferiority in using the knife or any other method?

Dr McMeekan: The main conclusion reached about castration
methods is that it does not matter two hoots which method is used
from point of view of its effect on the lambs provided the method is
properly used. The choice of knife or ringing is purely individual.
I find some men prefer and are better with the knife than with rubber
rings with which they are clumsy.

Mr Butcher, Broadfield: Many of us are apprehensive of the
spread of eczema in the South Island. Is there any relationship
between facial eczema and low potash?

Dr McMeekan: There seems to be no relationship between facial
eczema and topdressing, or facial eczema and trace elements of any
kind. It occurs on land never topdressed. There seems no associa­
tion between facial eczema and the type of pasture. The incidence is
more frequent the higher the overall productivity of the farm. It is
difficult to describe the conditions where it is likely to occur. In the
North Island the Met. Office records regular data of grass and soil
temperatures for all districts on a weekly basis. They pass on this
information and facts about the general climatic situation to Dr
Filmer who issues a general facial eczema warning. He sends this to
local officers who decide whether to issue it to farmers in their par­
ticular district. The conditions favouring eczema are: high soil
temperatures; high air and grass temperatures; rainfall following a
period of dormancy in growth (that does not mean that the pastures
have dried up); and a very rapid rate of growth of the pasture. We will not be able to more accurately define the weather and field conditions under which eczema occurs until we have successfully identified the precise chemical toxin involved and until we have devised a simple chemical procedure for detecting it in pastures. The real problem with facial eczema is that by the time you have got it, it is too late to do anything about it.
THE USE OF HORMONES TO CONTROL THE TIME OF LAMBING AND THE LAMBING PERCENTAGE

L. R. Wallace, Ruakura.

(In the absence, through illness of Dr Wallace, his paper was read by Dr McMeekan.)

There is, I feel, little need for me to stress the very great importance of the lambing percentage level in relation to the well-being of our sheep industry, and it must be agreed that in most districts there exists tremendous scope for improvement in this respect.

Many factors contribute to the low lambing percentages that are only too often obtained. Thus, some ewes die before lambing and some fail to lamb. Lamb losses, both at the time of birth and during the first few weeks of life, can be distressingly heavy; they are probably seldom less than 10 per cent. and may exceed 20 per cent. One of the most important considerations, however, is undoubtedly the low average number of lambs produced by the ewes which do lamb.

Now we come to the crux of the problem. The number of lambs produced by a ewe depends to a very great degree on the number of eggs that she sheds at the time she is mated. It does not depend entirely on this, for some of the eggs shed may not be fertilised or may die at some stage after fertilisation, usually during early pregnancy. But if only one egg is shed there can be only one embryo and only one lamb is born, whereas if two are shed the odds are in fact, rather better than two to one that twins will be produced. Hence, if a good lambing percentage is to be obtained, a high proportion of the ewes must be made to shed two or more eggs.

This can be achieved in a number of ways. It can be done, for instance, by a properly executed flushing programme. This morning I want to tell you about another method—one which few, if any, of you will at present be familiar. It is a method which has become possible only as a result of a considerable amount of investigation carried out in many different research laboratories. It is a method which involves the injection of hormone materials, and one which I have been developing and trying out at Ruakura over the last few years.

In order that you should understand the basis of the method it is necessary that you should understand something of the normal process of reproduction in sheep. As you know, most breeds of sheep are unlike cows in that they will not breed all the year round. It is only during part of the year that the ewes can be mated; during the remainder of the year they are just not interested in the rams.

At Ruakura Romney ewes usually start coming into heat towards the end of February, although many may not have their first heat until well into March. These times may vary quite considerably for other districts. The length of the heat period varies a little, but the average is about 30 hours. After a ewe has once come into heat, she will normally continue to do so at fairly regular intervals of 16 to 17
days until about August, which represents the end of the breeding season; unless of course, she is successfully mated, in which case she will normally have no further heat periods while pregnancy continues.

Now, the ewe's eggs are produced in small bodies called the ovaries. There are two of these, each about the size of a large raisin, one lying on either side of the body. Each ovary is surrounded by a delicate funnel-like structure which narrows down into a fine tube leading to the womb.

During the breeding season there are usually a number of small blisters present on the surface of the ovaries, and during the three to four days before a ewe comes on heat one or more of these grows rapidly bigger. Each of these blisters is filled with a watery fluid which contains a substance called oestrogen and each also contains a single ripening egg. By the time the ewe comes into heat these blisters have become quite bulging and very thin-walled and a few hours after the end of heat one or more of them bursts, releasing the egg. The egg passes into the funnel where, if mating has taken place, it is fertilised by a sperm from the ram and then travels down the fine tube into the womb.

Now, when a blister bursts it collapses like a ruptured balloon. However, the cells lining the walls of the burst blister multiply rapidly and soon the whole cavity is filled with a solid mass of tissue which is called the "yellow body." This yellow body grows larger during the next few days and reaches its greatest size about 10 to 12 days after heat, when it is about the size of a pea. If the ewe becomes pregnant, the yellow body persists throughout pregnancy. If the ewe does not become pregnant, it starts to die away after about the twelfth day, and as it dies away another crop of blisters begins to grow and the whole process is repeated. I would like you to remember about this yellow body, how it is formed after the end of heat, how it grows and then dies away before the next heat, for it is very important or at least it produces a very important substance called progesterone, about which I will have more to say later on.

We are now in a position to ask two very important questions. First, what causes the blisters to grow and the eggs to ripen during the last few days before heat, and secondly, what causes the ewe to come on heat? Clearly, if we know the answer to each of these questions, we may be able to help control things to our advantage, either by doing something to make the ewe ripen more than the usual number of eggs, or by making her come on heat at times when we want her to rather than whenever she feels inclined.

Let us take these questions one at a time. The ripening of the eggs is normally caused by a hormone substance produced by a small gland, the pituitary, situated at the base of the brain, and the greater the amount of this substance released by the pituitary into the bloodstream the greater will be the number of eggs ripened. Now, some years ago it was discovered that a substance which has very much the same effect is present in large amounts in the blood of pregnant mares between the 45th and 90th day of pregnancy. If mares that are in foal are bled at this stage, the blood collected and allowed to clot, and the serum obtained, and if then about one-sixth of an ounce of this serum is injected under the skin of a ewe a few days before she is due to come into heat, it will cause considerably more than the usual number of eggs to be ripened and shed. Indeed, if a fairly high dose level is used, instead of the normal one or two eggs, a dozen or more may be produced.

In practice, it is very important not only that the correct dosage is used, but also that this be given at the correct time. If the dosage is too low, a worthwhile increase in lambing percentage will not be
obtained. If the dose is too high, there is a double risk involved; an unduly high proportion of the ewes may fail to conceive and return to the ram, and rather many of the ewes that do conceive will produce too many lambs. At Ruakura, high dosage levels have been used in some experiments and occasional sets of quadruplets, quintuplets, and sextuplets have been born. Such lambs are very light at birth and many of them fail to survive. Also, with such multiple pregnancies there are increased ewe losses during pregnancy.

Provided the correct dosage levels are used, these troubles are largely avoided, and, as a result of work at Ruakura, we now know what the correct dosages are for Romney ewes and we also know that best results are obtained from ewes injected on either the 12th, 13th, or 14th day after heat.

In applying this method in practice, the following procedure is adopted. The ewes to be treated are run with raddled teaser rams. Every third day, the ewes tupped by the teaser rams during the previous three days are marked in some way so that they can be drafted out and injected 12 days later. As soon as they have been injected, the ewes are turned out with fertile rams. In our experience we have found it convenient to draft from the main flock at intervals of 12 days those ewes marked by the teaser rams during the previous 12 days. This smaller group of animals can then be kept nearby and brought into the yards every third day in order to draft off and inject those due for treatment.

### TABLE I

EFFECT OF P.M.S. ON LAMBING PERCENTAGE

<table>
<thead>
<tr>
<th>Group</th>
<th>Lambing Percentages</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lambs Born per 100 ewes lambing</td>
<td>Lambats alive at 28 days per 100 ewes lambing</td>
<td></td>
</tr>
<tr>
<td>Untreated</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Low dose P.M.S.</td>
<td>131</td>
<td>116</td>
<td></td>
</tr>
<tr>
<td>High dose P.M.S.</td>
<td>178</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td></td>
<td>192</td>
<td>145</td>
<td></td>
</tr>
</tbody>
</table>

The results obtained at Ruakura by this method have been quite encouraging. Pregnant mare serum treatment has not made the ewes any more difficult to get in lamb. A normal percentage has held to first service by the fertile rams and there has been no increase in the number eventually failing to get in lamb. It has led to a substantial increase in the number of lambs born, this increase being entirely due to a higher proportion of multiple births among the ewes that conceived at the first heat after injection. The ewes that do not conceive at their first mating, but which get in lamb later on, produce only a normal number of lambs. The results that were obtained in one trial carried out at Ruakura in 1953 are shown in Table I.

There is not the slightest doubt that the method outlined provides a thoroughly reliable and effective way of obtaining considerably improved lambing percentages. It has, however, certain disadvantages. In the first place, teaser rams have to be used and these cost money, although low-priced animals are quite suitable for the purpose. Secondly, there is the labour involved in carrying out the treatment. The teaser rams have to be caught and raddled fairly frequently and the ewes inspected at least once every three days to mark off those tupped during the previous three days. Every third day there
is also the work of drafting off and injecting some of the ewes. Lastly there is the important consideration of the effect of the treatment on the time of lambing. On many New Zealand fat lamb farms the rams are put out with the ewes at the beginning of March or even earlier. This coincides with the beginning of the breeding season and most ewes are normally mated by the rams at their first heat period. With the pregnant mare serum injection method ewes cannot be mated before their second heat period so that lambing is likely to be delayed by about a fortnight. Under certain circumstances this may be a serious disadvantage, as, for instance, where early lambing is practised with a view to getting a high proportion of the lambs away to the works fat off their mothers before pasture growth slows and its quality deteriorates with the advent of dry summer conditions.

Recently I have been trying a modified method of treatment to overcome these disadvantages. Clearly, what is needed is some means of inducing the ewes to come into heat together at some predetermined time, for then teasers would not have to be used, the whole flock could be treated over a comparatively short period, and lambing could be arranged to occur at the most convenient time.

CAUSE OF ONSET OF HEAT

Now research work recently carried out overseas has shown that in ewes the onset of heat is controlled by the action of two hormones, progesterone and oestrogen. Progesterone, it will be remembered, is the hormone substance mentioned earlier which is produced by the yellow body which develops in the ovary of the ewe after an egg is shed, and oestrogen is to be found in the fluid contained by the blisters which ripen during the few days before a ewe comes into heat. What happens during the normal breeding season is that between heat periods the ewe first receives a dose of progesterone produced by the yellow body and then, as this dies away, a dose of oestrogen produced by the newly ripening crop of blisters. As a result of the combined action of both these hormones, she comes into heat.

Before the breeding season begins, however, the ovaries of a sheep are quite inactive. No eggs are ripened, no yellow body is formed, and in consequence neither oestrogen nor progesterone is produced, and so the ewes do not come into heat. But if the necessary hormones are artificially supplied, they can be made to do so.

The technique which, so far, has given best results, consists of first treating the ewes with progesterone for a few days and then, not with oestrogen itself, but with pregnant mare serum. The purpose of the pregnant mare serum is to cause the blisters which will produce oestrogen to grow, ripen, and shed their eggs.

At Ruakura we have been working to find out the minimal amount of the two hormones that are needed to bring the ewes into heat and to make them shed a sufficiently large number of eggs to ensure a really good lambing percentage. Last year we found that an eight-day course of progesterone treatment gave better results than a shorter one of four days, or a longer one of 16 days, and some promising results were obtained. In one trial a group of 96 five-year-old Romney ewes that had not previously been in heat, were injected with progesterone each day for an eight-day period and then given a single injection of pregnant mare serum and turned out with fertile rams. Ninety-one came on heat and were mated within seven days of the last progesterone injection, and 81 of these became pregnant. These were killed and examined when a month in lamb. Forty-eight of them had a single lamb, 28 had twins, five had triplets, and one had quadruplets which gave an average of one and a half lambs per ewe.
It is of interest to compare the performance of these 96 treated animals with that of 32 ordinary untreated ewes which were grazed with them throughout the tupping period. Thirty became pregnant in late February and March and when these were killed a month later, 27 each had a single lamb and three had twins, an average of 1.1 lambs per ewe.

This year we have experiments in progress to find out how frequently it is necessary to inject the progesterone during the treatment period. From results obtained so far it appears that the ewes need to be injected only every second or third day.

There are one or two points about this progesterone method of treatment that deserve mention. The first is that there is nothing difficult involved in the operations that have to be carried out. Teaser rams are unnecessary, no tupping records have to be kept, and no drafting up of the ewes is required. And as far as the injections are concerned, in my opinion much less skill is needed than is needed, for instance, to castrate lambs, trim their feet, and crutch and drench them.

The second point concerns the number of ewes that should be treated simultaneously. Although it would be quite possible to treat the whole of a flock of, say, 1,000 ewes so as to bring most of them into heat during the same two or three days, it would certainly not be desirable to do so on account of the rams which would be grossly overworked if this were done. Clearly the sensible thing to do would be either to stagger the treatment of the ewes over a reasonable period; or, to mention an interesting future possibility, artificially inseminate the ewes.

Technically, it is no more difficult to inseminate ewes than cows, and the A.B. technique could be employed most easily under conditions where virtually all the ewes in a flock could be brought into heat over a period of two or three days. Costs might be rather high, but so they are with natural service at the present time, for with Southdawn rams costing 30 guineas apiece, I estimate it costs about 4/- or 5/- to get each ewe into lamb.

The third point concerns the possible practical importance of being able to control accurately the date of lambing. During the last few seasons a substantial premium has been paid for fat lambs drafted sufficiently early in the season to reach the British market before Christmas. Should this premium continue to be paid, producers might well become interested in having at least a proportion of their ewes lamb somewhat earlier than at present. Usually this cannot be done simply by putting the rams out earlier but could be accomplished by progesterone treatment.

The fourth point concerns facial eczema, which in certain districts less fortunate than this, constitutes a major hazard for fat lamb producers each autumn. It only too frequently happens that before and during tupping breeding ewes have to be heavily concentrated upon small areas to prevent their consuming toxic pasture. Flocks confined in this way are usually subject to a very low plane of nutrition and for this reason can be expected to produce only a small proportion of twins at lambing. Under such circumstances the pregnant mare serum or progesterone technique should prove particularly useful. The ewes are normally kept in small paddocks near the sheep yards, which would enable the injections to be conveniently performed, and very worthwhile increases in lambing percentages would result from treatment.

A few remarks about the nature, availability, and cost of the two hormone materials used may be of interest. Progesterone can
be manufactured synthetically. It is still expensive, but much less expensive than it was a few years ago. The present cost per dose is about 2/-.

Commercially prepared pregnant mare serum is readily available but it is even more costly. The price might well become reduced, however, if there were a large scale demand. As already mentioned, pregnant mare serum is obtained from the blood of mares between the 45th and 90th day of pregnancy. If bled at intervals over this period one mare should provide sufficient material to treat about 500 sheep. Perhaps in the future the New Zealand race horse industry may greatly assist the sheep industry by providing large quantities of pregnant mare serum.

The main purpose of this talk has simply been to tell farmers of some of the hormone work which is being carried out at Ruakura. The ultimate aim is to provide a method which can be easily and economically applied on farms to ensure that a good lambing percentage is obtained and that the lambs are born at the most convenient time. I have tried to give you some idea of the theory behind this work, of how it is being undertaken, and of the results so far achieved. I would emphasise that the work is still in the experimental stage.

DISCUSSION

Mr Earl, Waikari: In connection with twin ewes, do they give a higher percentage in a normal flock?

Dr McMeekan: I take it you refer to the story I told this morning on the attempt to improve lambing percentages through breeding. In our selection technique, one flock is selected on basis of high twin rate, i.e., ewe hoggets are from ewes with a long history of twinning. The flock selected for low lambing percentage had only ewes which had a long history of singles. In the intermediate flock, no attention was paid to family history. On the rams' side, the selected rams were themselves twins, and from ewes of five or six sets of twins breeding history. At the other end of the scale were rams from ewes with a long history of singles. The actual figures were 13 per cent difference between the high fertility flock and the low fertility flock. The difference was ten per cent at the start. So we are still in the position of not having got far by selecting on a basis of twinning.

Mr Holderness, Gebbies Valley: Dr Wallace mentioned the work that has been carried out on Romney ewes with pregnant mare serum. With ewes that are usually rather poor as far as fertility is concerned, he has shown that the lambing rate can be substantially increased. The Romney ewe is not only low in fertility but also is a poor milk producer. Some would rather have one good single lamb than two poor twins, but if we can make sure we get two instead of one is it not possible that something could be done to improve the milking ability of the Romney ewes together with the increased fertility?

Dr McMeekan: All the factual evidence about the milk-producing capacity of the Romney ewe in New Zealand is that on average she gives more milk than a single lamb can take. It would be better if she had twins. I am not convinced there is anything inherently wrong with the milk yield of the Romney. I have not known a farmer yet who would not be happier with 130 per cent lambs from Romney ewes than he is with under 100 per cent. He'll get them fat. Another aspect of the fat-lamb work is that of early weaning. From quite a
lot of work done now I am convinced early weaning of lambs under
fat-lamb conditions is essentially a sound practice, particularly if the
sheep on the farm are likely to meet a diminishing food supply quan-
titatively and qualitatively from December onwards. Food put to the
lamb through the ewe is uneconomic if the lamb can take that food
direct. Making the least possible use of the mother and the most
possible use of grass direct is the best method. This applies not only
to sheep, but to all classes of animals.

Mr McKenzie, Southland: In regard to unthrift in hoggets, do
you give them exercise? When pulpy kidney first started it was kept
in check a great deal by exercising ewes and lambs. They were
driven about one mile and then left to drift back.

Dr McMeekan: We have never carried out experimental compari-
sions of exercise in relation to ill thrift. There have been a lot of
observations on steep hill country. Spreading hoggets out extensively
on hilly country is successful provided there is long feed on the area
concerned. It is a failure if the food is short. There is something
about autumn pasture under certain conditions which makes the young
sheep refuse to eat nearly enough of it.

Professor Coop: I am not entirely satisfied with the answers.

(1) This business of breeding from twins. Dr McMeekan said he
started off with a difference of ten per cent; normally if you started
with this you would breed back to zero. We have under-rated the
success of the experiment you have carried out.

(2) Satisfaction with the milk production of the Romney. It has
been said, and with a fair amount of proof, that a Romney ewe pro-
duces all the milk a single lamb can take. In a stud flock, the milk
production as measured by the rate of growth of lambs up to 50 or
60 days, the difference between the best ten per cent and the worst
ten per cent is two to one (best 50 lb, worst 25-30 lb). This applies
to all breeds. There is something wrong if a lamb is only 30 lb at
60 days. If ewes are going to have twins and triplets you may not
be able to fatten all the lambs. Cross breeding with Cheviot or Border
Leicester does in fact increase milk production, whereas Dr Wallace's
methods do not.

Dr McMeekan: (1) It depends on the point of view. Selection as
a basis to improve the Romney breed is worthwhile, but it may need
100 years.

(2) I am not satisfied with the milk yield of the Romney breed
but I am not convinced there is much wrong with it. So far as the
observation is concerned of a two to one difference within a Romney
clock, I say we get the same sort of effect within other breeds as well.
Individual females vary materially in their individual milk yield. I
would like to see Romneys produce more milk for a longer time (two
weeks)—the lactation period is a bit sharp for fat-lamb growth. For
a breeding policy to be of any use to fat-lamb farmers, hill country
farmers must breed cross-bred sheep; it will be a long time before
such a policy is universally adopted. My own judgment is this: All
these methods have their uses and will find their place in the industry
in relation to the particular circumstances. Flushing, cross breeding,
selection and stimulation by hormones, are four techniques now avail-
able. So far as the Romney is concerned in Southland, the main thing
wrong is that too many get too fat too soon.

Mr Topp, Waipara: I hope that in six years my total flock of
2,500 ewes will be all twins. I feel a lot can be done in improving
the milking quality of ewes. My method has a lot in favour of it. I
pick out my twin ewes; if they measure up to a pretty high standard
it indicates they have had a good-milking mother. If the lamb is
not good, the mother cannot have had much milk. By picking well-
grown twin ewe-lambs you can improve the milking quality of the
ewes.
INFERTILITY IN RAMS

J. W. McLean, Lincoln College.

It is now a little over ten years since Crawford commenced, on a large scale in the Gisborne district, the practice of assessing the breeding potential of rams by manual examination, or palpation of their scrotal contents.

The rams were examined just before mating and classified into three classes. (1) "Sound," consisting of normally flushed rams ready for use—comprising about 70 per cent of all rams examined; (2) "temporarily infertile," consisting of unflushed rams, not yet ready for use which should be fed and turned out later—about 20 per cent of all rams; and (3) "probably poor breeders" comprising on average about ten per cent, which, it was recommended, should be culled in the belief that they showed "permanent lesions."

The purpose originally was to turn out only fertile rams, and in so doing, to increase the lambing percentage—which was known to be relatively low in the area. Figures have been quoted purporting to show that an increase in lamb crop—or above four per cent—did in fact occur, and that the lambing was more compact.

Because it is relatively simple to do, and the demand for it has been great, the technique has been applied widely by veterinarians, until now any farmer who doesn't have his rams examined is regarded at least as unprogressive, and perhaps as not having the best interests of the country at heart.

With the rapid extension of such a procedure, it was almost inevitable that certain anomalies would have arisen; and this has been so. For various reasons, misunderstandings have arisen among farmers, between farmers and farmers' organisations, and sometimes between farmers and their veterinarians.

In this short paper I want to summarise for you some of the latest information about the conditions revealed by this procedure in the hope that the chances of misunderstandings in the future will be reduced.

What does palpation of the scrotal contents reveal?

It is well known that ewes of the standard English breeds exhibit a well defined "breeding season" starting about the end of February and ending about July or August, during which time their reproductive organs undergo cyclical changes resulting in "heat" and ovulation over 16-17 days. It is not so well known that rams also experience seasonal changes in reproductive activity. While they may work and actually leave lambs at any time of the year, they are much more active and fertile when they become "flushed" in the autumn, at a time corresponding approximately to the beginning of the breeding season in ewes.

Associated with the "flushing" of the skin, the testicles and their associated structures—the epididymes increase in size, turgidity and functional activity. With experience, these changes can be recognised by manual examination of the organs; thus "flushed" rams can be distinguished from those not yet ready to be turned out. In addition, it is possible to identify irregularities in structure, such as abnormal variation in the shape, size and consistency of the testis and epididymis. I would like to stress the fact that experience is neces-
sary, because there is considerably variation due to individuality, age, breed, etc., which is normal. Frequently the epididymis is found to be affected, and this has led to the common use of the term “epididymitis,” which means technically an inflammation, from any cause, of the epididymis. It must be appreciated, however, that the testicles are also frequently involved.

Because rams with obvious lesions were regarded as sterile, or likely to become so in time, it was assumed, by inference, that those free of such abnormalities were fertile, and the examination became known among farmers as a test for fertility. Let me say here and now that it is not a test for fertility, it never was, and in my opinion, it never can be; and it would be even less reasonable to call it a test for sterility.

To illustrate, let us take say 100 rams rejected for various kinds of lesions in one or both testicles, etc. I would estimate that at least 20 per cent of these would be fertile. The other 80 per cent would be sterile or of lowered fertility, but perhaps a quarter of them would recover and become fertile in time. Now let us take 100 rams with “normal” organs, as far as can be ascertained by palpation: I would estimate that about 90 per cent or so would be fertile and likely to remain so.

Look at this another way, and apply it to an individual ram; if it has normal organs, the chances are nine to one that it will be fertile; you would be wrong, however, once in ten times, if you called it fertile. In the same way, with a ram with so-called “epididymitis,” the chances are four to one that it will be sterile at the time, and you would be wrong once in five times if you state that it is sterile.

Please understand that these are only estimates, educated guesses if you like, but they illustrate an important point, i.e., because a ram has normal reproductive organs on palpation, it is not necessarily fertile; and because it has abnormal organs, it is not necessarily sterile.

I shall refer to the significance of this later when we consider the desirability of applying the test to all rams presented for sale at ram fairs.

Brucellosis in Sheep

About five years ago, it was shown for the first time that the commonest cause of these “lumps” in the testis and epididymis—but not the only cause—was a microbe or germ, later to become known as a type of Brucella melitensis. It is customary therefore to refer now to the disease in sheep caused by this organism as Brucellosis.

Brucellosis in Rams

The disease is apparently transmitted in a typically venereal fashion. Infected rams frequently excrete the organism in their semen and thus transmit the disease directly to ewes, and indirectly to healthy rams mating with such ewes at the same heat period. Ram to ram infection therefore occurs mainly during the mating season, and particularly towards the end, when there are few ewes left to be served by many rams. Young rams may spread the infection by mounting one another.

Many weeks may elapse from the time of infection till palpable lesions develop in the testicles and some infected rams, perhaps ten to 15 per cent, show no clinical abnormalities at all. The absence of palpable abnormalities cannot therefore be taken as evidence of freedom from infection.

On the other hand, because there is obvious epididymitis, it does not follow that the ram has Brucellosis, or even if it has, that it is excreting the organism in its semen—the important point being that “epididymitis” may be caused by other infections and by mechanical injury.
Manual examination of the testicles therefore is not only an uncertain method of diagnosis of Brucellosis but it may also be misleading.

While the normal course of the disease leads to extensive damage to both testicles and epididymes, resulting ultimately in permanent sterility, this does not happen in all cases. A few recover completely without treatment and return to normal healthy fertile animals. Furthermore, it has been shown that rams with extensive lesions, associated with poor semen quality, may be successfully treated with certain drugs—though the cost at present is high. And finally, in some, the lesions remain in the epididymis, but the semen quality returns and the rams regain their fertility.

*Brucellosis in Ewes and Lambs*

In pregnant ewes the infection causes injury to the points of attachment of the foetal membranes to the uterine wall, which may lead to the death of the unborn lamb and abortion usually late in pregnancy. The abortion rate, as a rule, is not high—about two to four per cent, but it may go up to 20 per cent. It is believed that ewes normally become infected from infected rams.

In addition to these abortions, it is suggested that the disease is a common cause of death in lambs at or near lambing—an important cause therefore of the so-called “neo-natal mortality” in lambs.

To summarise then, Brucellosis is responsible in New Zealand for the great majority of infections of the genital organs in rams that lead to temporary or permanent sterility; it is the cause of a high proportion of the abortions in ewes, in late pregnancy, particularly in young sheep; and it is associated with lamb deaths at or shortly after lambing.

The disease is probably present in about 50 per cent of flocks in Canterbury and probably in more than this in the North Island.

The disease can be diagnosed much more accurately by suitable blood tests. Over the last few years, a method of control based on vaccination has been investigated and it is likely that a useful vaccine will be available in the near future.

We have seen that it is not possible accurately to determine the fertility of rams by manual examination of the reproductive organs. In a small but significant proportion of cases, rams with normal organs are sterile, and those with abnormal organs are fertile.

A more accurate assessment of fertility can be made by examining a semen specimen for such characters as sperm density, motility, morphology and pH, etc. But even this is not 100 per cent accurate. The final test and the only really reliable one is the mating test—i.e., can the ram successfully settle a reasonably large number of ewes in about five weeks?

Palpation of the scrotal contents is even less reliable as a means of determining whether or not a ram is infected with Brucellosis, i.e., he may have normal testicles and be infected, and have abnormal testicles and yet be uninfected. It is certain that the practice of eliminating clinical cases before tupping cannot be relied upon to prevent the spread of infection during the mating period.

*What purposes then are served by the procedure?*

I want to make it clear that I do not think the practice is useless. It is well worth while when it is used for its original purpose—that of turning out only presumably fertile rams and eliminating likely permanently sterile ones.

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Repeated examinations over several years have reduced the incidence in some flocks to nil. These flocks were probably not infected with Brucellosis. In other flocks the incidence has been reduced to two or three per cent and seems to remain about this level—these are almost certainly infected flocks.

Elimination of infected male animals could reduce the losses of rams from disease, by reducing the chances of spread during mating, and perhaps also the losses of lambs from abortion or death at lambing, but it could not, in my opinion, eliminate the infection.

While manual examination may be quite rational and helpful when used in flocks for any of the above-mentioned purposes, where errors associated with the procedure are not of great significance, the findings on any individual animal must be interpreted with the greatest caution. This is where most misunderstandings have arisen in the past. Farmers tend to regard each and every ram which passes this examination as fertile—and now, perhaps also as free of disease—and they look upon it almost as a guarantee to this effect, particularly when the examination is carried out by examiners officially appointed by organisations such as A. and P. Associations.

Now I am sure that no one can reasonably give such a guarantee on this type of examination. Conversely, it is equally unreasonable, that, because a ram does not pass such an examination, it should be designated as sterile or incurably diseased: some cases could with practical certainty be so designated, but many could not.

While I believe that a strong case could be made for the elimination from fairs of all rams showing any abnormality of the reproductive organs whatsoever, which might render them less able to do their required task, there is surely little justification for lumping these unceremoniously with all the other “rejects” to suffer the inexorable fate of having their throats cut.

Desexing or slaughter may be a reasonable verdict in passing judgment on sires with strongly heritable defects or undesirable breed characteristics, so that future generations are safeguarded, but it is surely not the inevitable end of a ram with a minor temporary abnormality of its reproductive organs.

If it becomes a question of freedom from disease, then I believe that other more accurate methods of diagnosis than palpation should be employed.

In individual cases, the procedure therefore should be an examination for what I would call genital soundness, that is, in the opinion of the particular veterinarian, at the time of the examination, the ram was free from palpable lesions of the testicles and associated structures, and that the other parts of the external genitals were normal in appearance. I believe a statement to this effect could be given with confidence and I think it would be worth while.

DISCUSSION

Question: Is this test really worth while?

Dr McLean: Yes, for the reasons mentioned. In special cases, if a more accurate assessment of fertility is required, a semen examination can be carried out. I do not think it is necessary however to go to the extent of a semen examination for ordinary flock rams.

Mr Neale, Marlborough: Assuming that we already have Brucellosis in our flock, how can it be eliminated? If a ewe has aborted, should she be culled on the grounds that she will continue to drop dead lambs, or infected lambs?
Dr McLean: First, because a ewe produces a dead lamb or aborts, it does not mean that she has Brucellosis. Even if she has Brucellosis, she may recover from the infection and produce normal lambs in later years. And secondly, elimination of such ewes from the flock could not be relied upon as a means of getting rid of the infection—in the same way, and for the same reason, that elimination of rams with abnormal testicles cannot be relied upon to get rid of the infection.

The control and elimination of infection in the flock will almost certainly depend on the development of an effective method of vaccination. This method of control is being tested at present.
FACE COVER IN SHEEP
I. E. Coop, Lincoln College.

INTRODUCTION

Man's attempts to improve domestic livestock have on the whole been remarkably successful. The dairy and beef cattle of today are better and more efficient producers than those of a century ago. In sheep equally important improvements have been made in the fleece of the wool breeds and in the conformation of the mutton breeds. Characteristics which are easy to measure have lent themselves to improvement, but in those characteristics which the farmer or stud breeder has difficulty in assessing—for example, prolificacy and milk production in sheep—it is doubtful whether any progress at all has been made and indeed we may even have gone backwards. Sheep-breeders have over the decades selected strongly for wool weight and quality in our wool and dual purpose breeds, to the neglect of prolificacy, mothering ability, milk production and longevity. We now have evidence that selection for wool alone has reacted adversely on prolificacy and milk production or on reproduction in its widest sense. The influence of the amount of wool on the face of a sheep, for which there has been positive selection, is a good example of what selection for wool alone, without reference to related reproductive characteristics, can do.

Ancestral and unimproved breeds of sheep were clear in the face, a necessity which was imposed if they were to survive under conditions of natural selection. Even as recently as 50 years ago our New Zealand breeds—the Romney, Corriedale, halfbred and Merino—were clear in the face, but that is not so today (with the exception of the Merino). In the past 50 years the stud breeders, in breeding for wool alone without recognising what effect this might have on reproduction, have slowly but surely put more and more wool on the faces of their own and everyone else's sheep. The harmful effects which this increasing face cover has on the productivity of the sheep has only recently been discovered by research workers in the United States of America and New Zealand. I propose to outline the experimental evidence concerning face cover, then to discuss the implications arising from this evidence, and finally to suggest what should be done.

Results from U.S.A.

The first suggestion that excessive face cover had harmful effects came from the United States of America. The results of a fairly comprehensive study in Rambouillet sheep were published in 1949. The Rambouillet is a merino type sheep and the environment in which these studies were made was the western range country of the U.S.A., country not unlike our Mackenzie Country in climate, terrain and carrying capacity. It was shown that covered faced ewes weaned about 15 per cent less lamb per ewe mated than did open faced ewes but they clipped 0.2 lb more wool. It was believed that the greater wool production of the covered faced sheep was due almost entirely to the fact that they produced fewer lambs. As a result of this work there has been a definite swing towards open faced sheep in the United States.

Results from Lincoln College

If these results could be substantiated in our breeds of sheep under our conditions the possibility existed of an important advance
in sheep breeding in New Zealand. Accordingly in 1950 we began to study the effect of face cover in our Ashley Dene flock and have continued to do so ever since. We have graded every sheep (usually just before crutching) into one of three categories of face cover—open, intermediate and covered—and we have kept the full production records of these sheep in terms of fleece weight, lambs born, lambs weaned, weaning weight, and so on. We then analyse all the data and compare the production of the sheep in the three categories of face cover.

The ewes and hoggets were subjected to the normal sheep husbandry practices—that is, ewes are given a light eye-wigging and ring-crutching in February and a full eye-wigging and crutching in June; hoggets are given a light eye-wigging and crutching at weaning and a full eye-wigging and crutching in June. It is important to realise that the face cover effects are obtained in spite of these eye-wiggings.

Initially the Ashley Dene flock consisted of pure Corriedale ewes and some Romney x Corriedale threequarterbred ewes, the former being used for breeding replacements and the latter for fat lambs. We naturally kept the records of these two types separate and have analysed them separately, but the results have been so similar that in order to simplify this paper I will consider them all together. The results are given in the following table.

<table>
<thead>
<tr>
<th>Per cent Grading</th>
<th>Live Weight</th>
<th>Lambs Born</th>
<th>Ewes Bared</th>
<th>Lambs Dying</th>
<th>Lambs Weaned</th>
<th>Weaning Weight</th>
<th>Relative Lamb Production</th>
<th>Fleece Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open</td>
<td>23</td>
<td>121</td>
<td>137</td>
<td>5</td>
<td>12</td>
<td>114</td>
<td>64</td>
<td>9.23</td>
</tr>
<tr>
<td>Intermed.</td>
<td>46</td>
<td>118</td>
<td>133</td>
<td>6</td>
<td>14</td>
<td>108</td>
<td>66</td>
<td>9.28</td>
</tr>
<tr>
<td>Covered</td>
<td>31</td>
<td>115</td>
<td>125</td>
<td>8</td>
<td>15</td>
<td>97</td>
<td>64</td>
<td>9.52</td>
</tr>
</tbody>
</table>

As far as ewes are concerned the results may be summarised as follows:

(i) Approximately one quarter of the ewes were graded open faced, nearly half intermediate and one-third covered.

(ii) The covered faced ewes are slightly smaller in size than open faced ewes.

(iii) The covered faced ewes clip 4 lb more wool than open faced ewes with a suggestion that the wool is of slightly higher grade.

(iv) The covered faced ewes wean just under 20 per cent less lamb than the open faced ewes, this 20 per cent being a composite of more barren ewes, fewer lambs born per ewe lambing, more lambs dying and lighter lambs at weaning.

(v) The intermediate faced ewes occupy an intermediate position but much nearer the open faced ones than the covered; for example they wean seven per cent less lamb than open faced ewes.

In the hoggets we find that covered faced ones are 3 to 5 lb lighter in weight, there is no difference in fleece weight, though fleeces from covered faced hoggets are of slightly higher grade.

During the last two years we have also investigated the College stud flocks of Corriedale, Romney and Southdown breeds. We find
the same sort of results as were found at Ashley Dene obtaining in all three breeds. The Southdowns had an even higher degree of face cover than the Romneys and Corriedales.

**Results from Ruakura and Massey College**

Similar studies have also been made recently in the Romney breed at the Ruakura Hill Country Station and at Massey College. At Ruakura the hill country flock was graded for face cover in 1950 into four grades—open, slightly covered, covered and very covered. Lifetime production records were kept and analysed. It was found that in terms of lamb production there was an even gradation from the open to the very covered faced ewes. Taking the extremes, the very covered faces produced 35 per cent less lamb at weaning than did the open faced ewes, this 35 per cent being a composite of several factors, of which barrenness was the most important. The covered faced group produced 22 per cent less and the slightly covered five per cent less than the open faced ewes. These differences are somewhat greater than the Lincoln and Massey ones, and this is to be expected because of the grading into four instead of three face categories. There was less consistency in the fleece weights but the general indication was that the covered faced sheep produce a slightly heavier fleece than the open faced ones. The Ruakura results suggested that most of the differences occur at the two-tooth stage whereas at Ashley Dene we found the differences to be of the same order at all ages.

The Massey College investigations have been in a flock of over 400 mixed-aged ewes run on good heavy country. They graded the ewes into three categories and in almost the same proportions as we did at Ashley Dene with a little over one-quarter of the ewes in the open faced grade and a little over one-third in each of the intermediate and the covered faced grades. From the results of the two years' work which have so far been published they conclude that the covered faced ewes produced about 20 per cent less lamb at weaning than the open faced ones—this again being a resultant of lower lambing percentage and lighter lambs at weaning. On the other hand the covered faced ewes clipped over one-third of a pound more wool.

**Results from Australia**

Merinos have much less wool on the face than have Romneys and Corriedales. We have no information about the effect on Merinos in New Zealand, but an interim report of an investigation started two years ago in New South Wales indicates that reproduction is adversely affected by face cover and that so also is wool. This Australian work suggests that covered faced ewes clip one-third of a pound less than open faced ones, in which respect it differs from all the New Zealand work.

It is obvious from the experiments which have been quoted that excessive face cover has a very serious effect on reproduction of sheep. The results in different breeds and from different research stations are all in exceptionally good agreement and leave no doubt whatever that they are correct. We—and by “we” I mean the research workers—are all agreed that covered faced sheep produce at weaning about 20 per cent less lamb than open faced ewes. This figure is obtained by combining the various effects such as increased barrenness, fewer twins born, more lambs dying and lower weaning weight of the covered faced sheep. We are agreed that the intermediate grade of face cover approximates more closely to the open than to the covered faced. With the exception of the Australian work, which is by no means complete, we are also in agreement that covered faced sheep clip more wool than open faced ones. The magnitude of this
difference lies somewhere between one-fifth and one-half of a pound; some of us think that the difference is due entirely to the fact that the covered faced sheep are rearing fewer lambs, but I myself believe that the difference is greater than can be accounted for by this means alone and that covered faced sheep are in fact inherently better wool producers. However, this is not of great practical significance since whatever the cause the gain in wool is so small economically compared with the loss in lamb production that we all know what kind of sheep we want.

There are some side issues to this main argument which have not been studied. For example, one would assume that since covered faced sheep produce fewer lambs, they would require less feed and that consequently more could be carried per acre. On the other hand the covered faced sheep would produce fewer ewe lambs or hoggets from which to select replacements and one would have a lower margin for culling. Then there is the problem of mustering covered faced sheep and of a possible greater death rate in covered faced hoggets. However, I feel that these would not alter very materially the conclusion which has already been drawn, and I believe that the results are so much in favour of the open faced sheep that there can be no argument at all.

I should perhaps make it clear than in an average flock in which approximately one-third of the ewes fall into each face grade the gain in lamb production through a change to 100 per cent open face would not be 20 per cent but would be one-third of 20 per cent plus one-third of seven per cent which equals nine per cent since you already have some open faced sheep. By a similar argument the loss in wool would be about one-tenth of a pound. The urgent task is to get rid of that one-third of the flock which is covered-faced.

The heritability of face cover is high, which in simple terms means that open faced sheep beget open faced progeny and covered faced sheep beget covered faced progeny. Consequently if you use open faced rams and if you select for open faces in your ewe replacements your flock will become open faced in a matter of a few years. Progress can be quite rapid. The main difficulty is that of finding open faced rams. You will certainly not find them exhibited at the shows. We must first convince the stud breeders and the Sheep Societies that we are serious about this business of face cover. We must convince them of the folly of the past, though in all fairness no one had previously proved the folly to them. They must begin by using open faced rams as their own stud sires, so that the stud stocks themselves become open faced and from then onwards an increasing number of open faced rams will be offered for sale to the ordinary sheepfarmer. Although open faced sheep are in a minority in the studs they are not extinct and a sufficient number exists from which progress could be made at a reasonably rapid rate provided action is taken. If the facts convince you that open faced sheep are desirable I suggest that it is in your own interests to use all the influence you possess to see that the nucleus of the sheep industry—the stud or ram breeding flocks, give us the kind of rams that we want.

Of course, an open face is not the only desirable characteristic of sheep and a sheep should not necessarily be selected solely on this account. All the other characteristics such as wool, carcase conformation, twinning and constitution must be considered along with face cover, but what is now suggested is that an open face is one of the most important characteristics on which selection should be based. Those of you who have been overseas, and to the United Kingdom in particular, must appreciate that the fertility or lambing percentage of our New Zealand sheep is low, bearing in mind our favourable climate and superior pastures. Several different methods of increasing our
Jambing percentage are under intensive investigation at our research stations and colleges. Face cover is only one aspect which indicates that significant progress is being made towards raising our lambing percentage to a more satisfactory level.

In conclusion may I say that while the fundamental causes of the remarkable differences in production between open and covered faced sheep are unknown, the fact that a difference of considerable magnitude and of considerable economic importance exists is proved beyond reasonable doubt. The practical issues arising from this seem fairly straightforward. It now remains for the sheep industry to take action.

DISCUSSION

Mr Hunt: What exactly can we farmers do about it? When we go to buy stud rams we must impress stud breeders to be sure to produce sheep with open faces.

Professor Coop: We can only do it over a fairly long period by a continuous campaign, always asking for and demanding open-face sheep and by telling the truth to stud breeders and sheep farmers until it becomes so obvious that the advantages of open face sheep are known to even the conservative stud breeder. There are one or two Romney open-faced flocks and one or two Corriedale. When buying you should display preference for open-face sheep; in the course of time stud breeders will produce them. If you criticise a stud breeder on the type of ram, he will say he produces what the farmers want. If you make it clear to him what you want then he has either got to produce what you want or else admit that he is not interested in breeding what New Zealand sheep farmers want, but has his own ideas. It is difficult to convince stud breeders to go back about 50 years and start their breeding ideas afresh.

Mr Slater, Geraldine: Dr McMeekan mentioned the factor of introducing Border Leicester blood into the Romney for a specific purpose. What do you think the dangers would be if the farmer deliberately took steps to introduce the Border into Romney flocks? Would it be advisable or would it be damaging to the wool?

Professor Coop: At Ashley Dene you will see that I am completely converted to the Border Leicester cross as a means of producing not only open faces but high lambing percentages and good lambs. Crossing sheep with the Border Leicester is a good idea quite apart from open faces. You may lose a little on wool, not much, but you would gain in total production.

Mr Earl, Waikari: (1) in connection with woolly-headed sheep is the conformation of lambs weak? (2) What about our Southdown breed? It is difficult to get a Southdown ram without too much wool on head.

Professor Coop: (1) I have not done any work on the conformation of lambs in relation to the face cover of the ewe. Lambs of covered-face ewes grow more slowly; therefore, I expect them to have worse conformation.

(2) The Southdown. The number of open-faced or intermediate-faced sheep in the Southdown is very low; 90 per cent are cover-faced. The stud breeder is the one who loses out because instead of breeding Southdown rams and ewes producing 130 per cent of lambs he is still producing those only giving 100 per cent. The other loser is the fat-lamb producer because the growth rate is lower than from open-faced rams. There is a lot to be said for opening up the face of all rams.
A speaker from South Canterbury: When crossing the Border Leicester with the Romney would that cross survive and thrive in the same category as the Romney? We know the Border is a quick-maturing sheep but it is no mutton sheep and we would be altering our carcase from a meat carcase to a fat carcase.

Professor Coop: We would not, on our present knowledge, advocate the use of the Border Leicester on hard hill-country; it is essentially a low-land sheep. The conformation of the Border Leicester is not as good as the straight Romney. When you put old ewes into the works it means they will be rather long in the legs and possibly fatter than is desirable. There is very little difference between conformation of lambs of the Border cross compared with lambs from the straight Romney. Lambs of the Border Leicester-Romney cross grow much faster so you get better carcase conformation just from this faster growth.
THE STORY OF THE EFFECT OF "1"
THYROXINE ON GROWTH OF WOOL
IN SHEEP

D. S. Hart, Lincoln College.

INTRODUCTION

In introducing the subject of this paper I should like to refer you to an incident which took place in August of 1951. A small group of farmers (some of them may be present today) who were visiting the College at that time asked me if I would show them through the experimental sheep pens. This I did, and after we had looked at the sheep in their blacked-out pens, with electric lights coming on and off at different times of the day, one of the group said: "This is quite interesting, but what is the good of it all to the farmer?" On that day in August, 1951, I could not answer him satisfactorily unless I said "None at all."

Today I propose to give that answer. But in so doing I wish to make one further point clear. This is the story of a piece of fundamental research which at the commencement showed no sign whatever of becoming economically important. Yet after five years' scientific research we have the discovery of a new use and application for the hormone "1" thyroxine which appears to be of definite economic value to the sheep-farmer.

I wish to strongly emphasise that this discovery might not have been made had a scientist not been allowed to spend a few pounds playing about with dark rooms, electric lights and sheep.

Effect of Light and Darkness on Wool Growth

It was in January of 1951 that a series of experiments was planned to test the effects of controlled light and dark periods on sheep. It was already well known that the breeding cycle of the ewe could be controlled by the amount of light and dark received every twenty-four hours, but our information went no further than that point. We suspected that the pituitary gland of the body was involved in some way, as we knew that the onset of the breeding season of the ewe was the result of stimulation of the reproductive hormone by the pituitary.

The pituitary is known to be concerned with nearly all hormones in some way or other and as a result it is often referred to as "the master gland of the body." The proper functioning of growth in an animal has been presumed to be connected with growth hormone, so one of several ideas was to test the effect on this of controlled light-dark rhythms, by using the growth rate of wool as a possible method of measuring growth hormone output in the sheep. In order to make sure all conditions were as standardised as possible between the different groups of sheep and between years of experiments, all the sheep were kept housed and fed with exactly the same amount of a balanced sheep food daily.

The results from the first year's work when two groups of Corriedale ewes were used, one, the light treated group, receiving a fixed light-dark rhythm of 8 hours light—16 hours dark per day, and the other, the controls, having the normal varying solar daylight rhythm throughout the year, were very interesting.
Fig. 1. Effect of light treatment on growth of wool.

As figure 1 shows, the light treated group produced about 15 per cent more wool than did the controls, which was a rather unexpected result. The experiment was repeated with a new line of sheep in the following year, 1952, with precisely the same result.

**Thyroxine Treatments**

There could be no doubt of the result now, so in 1953 it was decided to see if hormones administered during the winter when natural wool growth is lowest, would produce the same result as the light treatment. Three different hormones were tried and it can be seen from figure 2 that two of these were successful and gave a response during the period of administration whilst one failed. At this stage it began to look as if we were on to something which might be of commercial use, so a decision to concentrate work on the one hormone “1” thyroxine was taken.

In 1954 then, an extremely comprehensive set of experiments was designed to cover the possibility of there being any harmful effects on the sheep.

As many aspects as possible were tested including non-pregnant, pregnant and lactating sheep, as well as those being tupped. Differing dose levels, in addition to different methods of administration, were also tried.

Several important facts emerged from this series:—

1. A live weight loss of approximately eight pounds occurs about 14 days after administration, the ewes recovering from this later.
Fig. 2. Effect of three different hormones on wool growth.
2. There appears to be no immediately obvious harmful side effects.

3. A suitable dose of the hormone could be administered in one operation by implantation under the skin.

4. The time of the year to give a single dose so as to obtain best results appeared to be between mid-summer and early autumn. An example of the response from a single dose given in early autumn is shown in figure 3.

![EFFECT OF 1 THYROXINE ON WOOL GROWTH](image)

Fig. 3.

It should be emphasised that up to this stage all experiments had been carried out on housed sheep in which the same amount of a standard concentrate food mixture had been fed daily to both control and treated animals. So the next stage was for Professor Coop to carry out some controlled field trials at Ashley Denes where it was still possible to measure the monthly growth rate of wool on ewes grazed under more or less natural conditions. The results from these trials were in line with those obtained in the housed sheep and indicated an increase of over three-quarters of a pound of wool per sheep implanted, with no reduction in lambing percentage or other harmful side effects being recorded. It was obvious therefore that the next step was to carry out a field trial under ordinary farm conditions. For this purpose one hundred five-year-old Border Leicester half-bred cross ewes were made available for experimental use, on the property of a co-operative, progressive farmer about fourteen miles from the College.

The sheep were divided into two groups of fifty and identified as such by group earmarks and paint brands. One group was implanted with thyroxine on 18 February 1955 and the other group was used as the control. Both the thyroxine treated and the control group were then joined with the remaining ewes on the property and received the normal flock management associated with that property throughout the year. The rams were put out in the flock the first week in March and lambing occurred normally in August. A careful check on the lambing performance of the thyroxine and control groups showed that there was definitely no lowering of the lambing percentage in the thyroxine group.
Wool Weights

Shearing took place on 9 November 1955, both groups being identified and shorn separately. The bellies were removed as in normal practice and each individual fleece was weighed, classed by a professional wool-classer and sampled. The greasy weights of the fleeces were as follows:

<table>
<thead>
<tr>
<th>Group</th>
<th>Total Fleece Weight</th>
<th>Mean Fleece Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group (47 ewes shorn)</td>
<td>399.0</td>
<td>8.48</td>
</tr>
<tr>
<td>Thyroxine Group (42 ewes shorn)</td>
<td>404.6</td>
<td>9.63</td>
</tr>
</tbody>
</table>

Thyroxine increase over controls of 1.15 lb of wool per sheep, which equals 13.5 per cent more wool produced.

It should be pointed out that due to mis-musters and failure to identify at shearing, three ewes were missed from the control group and eight from the thyroxine group; four of the latter were mustered later but could not be included for the obvious reason of having had a longer wool-growing period.

Wool Quality

The results from the grading of the fleeces by expert commercial wool-classers working on New Zealand standards were as follows:

<table>
<thead>
<tr>
<th>Grades</th>
<th>A's &amp; BB's</th>
<th>B's</th>
<th>C's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>18</td>
<td>21</td>
<td>8</td>
</tr>
<tr>
<td>Thyroxine</td>
<td>31</td>
<td>11</td>
<td>0</td>
</tr>
</tbody>
</table>

This shows that there has been an undoubted improvement in grade resulting from the thyroxine treatment, and if the average price difference between grades were taken as threepence per pound the commercial value is obvious.

Yield

Subsequent test scouring of the samples taken from each fleece was very kindly undertaken by Dr Henderson's Wool Department at the College with the following results:

<table>
<thead>
<tr>
<th>Group</th>
<th>Fleece yield per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>65.4</td>
</tr>
<tr>
<td>Thyroxine</td>
<td>66.0</td>
</tr>
</tbody>
</table>

Interpretation of this difference of over a half per cent in favour of the thyroxine group is difficult as the numbers are not quite sufficient for significance, but if anything were to be deduced it could be that there is a tendency for the wool from thyroxine treated sheep to be slightly higher in yield.

Thus as the result of our implantation of approximately 90 mg of "I" thyroxine per sheep not only do we get an increase of 13.5 per cent in weight of wool but also a valuable increase in the quality of the wool produced. Further, this result was obtained in an ordinary commercial flock subjected to average conditions, the only extra work entailed being the implantation of sheep. This is best done in a crush race, with the operator moving through the sheep as each one is implanted. The operation is done with an implanting gun, the pellet being placed just under the skin behind the shoulder, and about three or four inches down from the middle of the back (see fig. 4). In this manner one man using a hand-loading gun can implant a race-full of fifty sheep in under an hour. An automatic gun is being developed and this will result in a speeding-up of the operation of implanting.

It is difficult at this point to make any reliable estimate of the costs of a dose of the hormone for one sheep. The Glaxo Laboratories N.Z. Ltd. who have to date been most helpful in supplying all the
thyroxine used free of charge, besides going to considerable trouble in designing and making the implant pellets in conjunction with their principals at Greenford in the United Kingdom, advise that the cost may be around about two shillings (N.Z.) per dose.

In conclusion I should like to point out that we still regard this work as being in the experimental stage and although there have been as yet no harmful side effects apparent, in spite of some sheep having been treated for three consecutive years, there is still a possibility which cannot yet be completely ruled out, that some may develop in the future. However, for the present it appears that Lincoln College can offer you an economic method for improving wool growth in sheep, which merits further large-scale trial and investigation.

In this connection you may be interested to know that over 1500 stud Romney, Romney cross, and Corriedale ewes have been implanted this season and the flocks concerned range from the Waikato to South Otago. If the results from these purposefully widespread trials prove favourable then reasonable supplies of the hormone should be on the market and available to farmers by the end of January 1957.

DISCUSSION

Mr Hunt: Does this have any effect on the lambing percentage?

Mr Hart: If I say anything regarding this question yet, it might be held against me. Unfortunately I am in a position where I will not be able to give a satisfactory answer to that until this coming May. We certainly have information which leads us to the conclusion that there is definitely no reduction in lambing percentage whatsoever; it might be the reverse. I beg leave not to answer this question at this time.

Professor Coop: With Southdowns some sheep get rather too fat in January, February and March. Mr Hart could have said this treatment takes the weight off and gets more wool in return. This could be another use of thyroxine.
Investigations on pastures on the Ashley Dene farm commenced in 1938 when the Department of Scientific and Industrial Research provided finance for a long term investigation into the management and production of subterranean clover pastures. Prior to this time pastures were composed of perennial ryegrass and white clover and were designed on the experience and success of these pasture plants on the more fertile and moister soils in different parts of the country. Some success had been obtained with cocksfoot and red clover but light land pastures were not expected to be permanent and in a year or two browntop, hairgrass and sweet vernal usually took charge. The real problems associated with these light dry soils were not recognised, but when these investigations commenced a search for the most suitable components of a pasture became the objective of research or field investigation.

The soil moisture conditions are so different from those of the more fertile lands that it is only reasonable to expect that pasture plants more particularly adapted to such conditions would be necessary to develop satisfactory pastures.

The soils are classified as Eyre shallow stony loam and Springston shallow stony loam. The Eyre shallow stony loam has a profile of four inches of light brown silty loam and one to five inches of bright orange-yellow silt loam on stones. The Springston shallow stony loam has a profile of four inches of dully grey stony silt loam, and two to four inches of pale greyish-yellow to ash grey stony silt loam on stones. There are approximately a million acres of these and related soils on the east coast of the South Island and small pockets in the drier regions of the North Island. The surface soil is shallow with a low moisture holding capacity and overlies an open shingle subsoil, also with a low moisture holding capacity. From a farming point of view the chief problems are related to these characteristics. From March through to mid-November moisture is generally adequate for growth of all pasture plants and growth can be extremely vigorous when temperatures rise in October and early November. From mid-November to March—a period of approximately four months—when temperatures are high, soil moisture is at its lowest and pasture growth is reduced to a very low level. At the beginning of this period high temperatures often associated with hot nor'-west winds can dry out the top soil to a considerable depth and a bulky herbage can dry off in the matter of a few days. What growth does occur is determined by any temporary surplus of rainfall/evaporation for most of the shallow-rooted plants and the subsoil moisture status for the deeper-rooted plants. These, then, are the particular conditions for which we have designed a pasture mixture which will be reasonably permanent and the production and management practices which will favour the establishment and survival of the sown plants.

The mixture consists of four types of plants:

1. Subterranean clover—the annual which survives the dry summer in the form of seed, germinates with autumn rains and, when conditions are favourable, provides some late autumn, winter and early spring grazing and a great bulk of feed in the spring and
early summer months. This is the pioneer legume for the light dry soils and one of the basic legumes for the new pasture mixtures.

2. Those perennial pasture plants which, because of their deep root ing habit and of their own water economy, can survive the dry periods and may produce some green herbage in all but the most prolonged and severe droughts. The plants which we have investigated that most successfully fulfill these requirements are the legume lucerne, and the grasses cocksfoot and Phalaris tuberosa.

3. Perennial ryegrass and white clover which are the recognised components of pasture under high fertility conditions which contribute to production under the improved fertility conditions following several years of subterranean clover pasture on light land, but which are liable to be severely affected by drought.

4. Short rotation ryegrass which is recognised as a temporary component of the pasture but which is useful in providing early grazing and in keeping weeds in check whilst the slower establishing permanent components are becoming established.

The long term investigation can be divided into four stages:

The first stage was a study of subterranean clover as a pasture plant in Canterbury and its response to different fertiliser treatments. This work showed that subterranean clover was a first-class pasture legume for these light lands and that it was essential to apply a combination of lime and superphosphate before a vigorous stand of the clover could be secured. This has been the general experience of farmers on these light dry soils.

The second stage was a study of the clover in relation to different grasses in the mixture. This relationship is complex and results from the fact that subterranean clover is a winter annual. Its normal behaviour is that it germinates in autumn, February to April, when moisture conditions become favourable, grows through the winter and starts flowering about the beginning of October while moisture conditions are generally still favourable. In good seasons profuse growth may develop through to December-January associated with prolific seeding. In an unfavourable season, however, several things may occur: (1) the clover may dry off before seed has formed; (2) the seed may form but fail to germinate; (3) the seed may germinate early but fail to survive; (4) the seed may germinate late and be killed by frost lift. With all these hazards the clover in a young stand may disappear from the pasture but in an old stand may regenerate to some degree from "hard" seed in the surface layers from past seasons' crop of seed. Failure to seed, however, has caused a marked reduction in subterranean clover in this district over the past two seasons, even in old stands.

Another major and widespread cause of poor establishment in a dry autumn has been the effect of competition for moisture between already established plants and the germinating clover seeds. We found that where a thick stand of ryegrass or cocksfoot existed following drilling of the normal seedings of these grasses, the clover germinated much less profusely than in a pasture where the density of the grasses was at a low level. As a result the pasture became deficient in clover and production fell. It was not an uncommon experience in the early years, when we were sowing at up to 20 pounds of ryegrass per acre, for a pasture to have very good subterranean clover in it for a year or two and then to gradually become grass dominant or grass bound with an unhealthy yellowish colour.

Subterranean clover is of such importance in these pastures that this state of affairs should not be allowed to continue for any length of time. We have found that the situation can be met in two ways.

55
The first is directed to recovering the balance of clover by top-working the field in January after the subterranean clover has seeded. This has the effect of reducing the density of the grass and thereby reducing the competition for moisture between established grass and the clover. At the same time it provides a more favourable seed bed and moisture for the clover seed which then germinates earlier than it would do without such top-working. The amount of top-working required will depend on the amount and kind of grass present and on whether the farmer plans to prepare a thoroughly worked seed bed in which to introduce some other seeds such as H1 ryegrass or oats to provide winter feed, or whether he plans to regain the initial vigour of the clover in the pasture. Whatever practices are adopted, this is an excellent procedure for reviving the old, run-out subterranean pastures and gives surprising growth of clover for winter feed as well as spring feed. It should be done in January.

The second method is directed towards preventing or at least discouraging the development of a dense grass sward by sowing much less grass than is usually sown and relying mainly on the clover to provide the bulk of feed, with only a sprinkling of grass. Such a mixture in our trials has given greater production over the third to sixth year of the life of a pasture, though in the first year after sowing the advantage was slightly in favour of the dense grass mixture, i.e., while the clover was still prolific in the pasture.

Grasses are desirable in the mixture to take advantage of the nitrogen added to the soil through stock grazing the clover. The grasses which we have found useful under these conditions, as previously mentioned, are the ryegrass, cocksfoot and phalaris.

Once the fertility has been built up following several years of subterranean clover, scattered plants of perennial ryegrass have a special value in providing late autumn, winter and early spring grazing, but the grass must not be too dense. I believe that 5 lb per acre drilled is too much because this develops into a dense grass sward too quickly under the now higher fertility of the surface soil. Two pounds appears to be adequate. H1 ryegrass can be useful but is a very temporary component of the mixture and, again, two pounds will provide useful winter grazing in the first year and will help to keep weeds in check but will not be so thick as to check the development of other sown plants.

Cocksfoot is a deep rooted grass and is more drought resistant than ryegrass. It can provide useful grazing in the summer, especially when rains allow short spells of growth. Plants tend to develop into tufts and too much cocksfoot presents a mechanical obstacle to clover establishment, so that again a lighter seeding of one to two pounds is recommended. Phalaris is another deep rooted grass which, when once established, is able to withstand or tolerate drought conditions. It does not grow much in the dry season but once moisture conditions become favourable it does produce a useful amount of herbage and will continue to grow into the cooler months. Another useful characteristic of phalaris is that it develops from an underground crown an open straggly growth in the midst of which subterranean clover will establish, and it does not present the same mechanical obstacle to subterranean clover as does cocksfoot. Four to six pounds will give a good balance of grass to clover.

These subterranean-based pastures have resulted in an increase in production but, for reasons stated earlier, subterranean clover can be unreliable in a dry autumn. When subterranean clover does not establish and grow vigorously production falls sharply and some weeds—particularly storksbill—can assume major proportions, as it has done in these past two seasons. At one stage I was willing to predict, based on the vigour and density of the subterranean clover in
April, when the rams were put out, the number of ewes which could be safely carried through the following season provided there was an adequate supply of winter feed. I still think that is possible, but the experience of the past two dry seasons has shown that when subterranean clover disappears something must be done about it. This has occurred on several pastures and we have been forced to attempt to regain the subterranean clover by surface introduction of from four to six pounds of seed per acre with and without surface working as soon as rains fall in February.

This, then, was the situation with regard to the subterranean clover based pasture at the end of the second stage of the work. It may be summarised as follows:

1. They require adequate lime and superphosphate.
2. There should be a low density of grasses (1-2 lb perennial rye, 1 lb cocksfoot, 3-4 lb phalaris).
3. They require top-working when grass becomes so dense that they hinder germination of vigorous clover.
4. Variation in production occurs, depending on the earliness of autumn germination.
5. Variation in re-seeding occurs, depending on spring and early summer drought.
6. There is need for re-sowing when re-seeding fails.

The third stage of the work commenced in the spring of 1949 when we included lucerne in a mixture. The results have shown that the pasture which has given the greatest production over a period of six years is one in which lucerne was added to the low density grass-subterranean clover mixture. The light seeding of grass is favourable for the establishment of the lucerne. The mixture sown in the early spring allows all the sown species to establish at a similar rate, and the suppression of the legumes (clover and lucerne) by a dense sowing of ryegrass is avoided. Autumn sowing of such a mixture may cause some suppression of the lucerne as the subterranean clover is going into its natural growing period while lucerne is going into its natural dormant period. Spring sowing well before the soil dries out, and the earlier the better, gives all sown plants an equal opportunity and the lucerne is less likely to be smothered by the clover. Once the lucerne is established there is little likelihood of the clover suppressing the lucerne in subsequent years. A disadvantage of spring sowing is that the clover may not flower and seed in time for early autumn establishment. In a favourable season it will do so and in an old subterranean field there would probably be sufficient seed to secure an autumn establishment, but in a new subterranean field it may be necessary to over-sow subterranean clover seed in January-February. The clover is so important in the mixture that this should be done where necessary. The mixture used, then, is:

Lucerne ................. 4 lb
Subterranean clover .... 4 lb
Cocksfoot ............... 1 lb
Perennial rye ........... 2 lb
H1 rye grass ............ 2 lb
White clover ............ ½ lb

This should be drilled in 3½-inch centres if possible.

Such a pasture has a very favourable combination of plants capable of providing maximum grazing under the special conditions existing on these light dry soils.

Following the growth through from the autumn when the moisture conditions favour the germination of the subterranean clover we have grazing from the clovers and grasses while the lucerne is declin-
ing though it may continue to provide grazing up to May when the frosts check growth. In the winter the grasses and the subterranean clover provide some grazing. In early spring the subterranean clover and the ryegrasses give early grazing which is soon supplemented by the lucerne. All the components in the mixture contribute to production in mid-October to mid-November. Then the subterranean clover and ryegrass begin to peter out and from, say, mid-November to mid-March the lucerne, with some assistance from cocksfoot and phalaris, provides the bulk of the grazing until ryegrass, phalaris and subterranean clover again take over in the late autumn.

It is appreciated that such a pasture can be subjected to different management to provide grazing at special times and the effect of this will influence subsequent growth, but we have found that they can be managed to provide (1) flushing feed for ewes, (2) some grazing during the winter, (3) lambing feed in the spring, (4) hay or silage crops in the flush of the season, (5) some lamb fattening feed in summer, and (6) maintenance in the late summer or autumn for ewes after lambs have been drafted.

The fourth stage commenced in the 1954-55 sowing season. Marlborough lucerne was the first variety used and at present we are carrying out investigations to compare the new grazing type of lucerne—M. glutinosa, Rhizoma and Nomad—with Marlborough. One field on the farm of one of the grazing types—M. glutinosa—has given the promising results which have encouraged extensive investigations into these new grazing types of lucerne. Many of you have seen this pasture and have followed its progress over the past nine years. Except for the fact that we have lost the bulk of the subterranean clover in the past two dry years the lucerne is as good as or better than ever. We are endeavouring to regain the clover by some surface work and over-sowing.

Just what proportion of the farm should be devoted to these pastures is being investigated. It could well be fifty per cent—I will hazard a guess that it will be nearer eighty. It is too early to say yet, but the proportion will be determined by the experience of the farmer who establishes first one field and then another, and another, in succeeding years. The change-over will be an evolutionary one as you gain experience of this new type of pasture.

TABLE I

Production in Terms of Dry Matter per Acre during First Full Season's Growth 1955-56 Season

<table>
<thead>
<tr>
<th>Component</th>
<th>1955-56 Season</th>
<th>Average 6-year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subterranean clover and dense grass</td>
<td>2965 lb</td>
<td>2053 lb</td>
</tr>
<tr>
<td>Subterranean clover and low density grass</td>
<td>3439 lb</td>
<td>2418 lb</td>
</tr>
<tr>
<td>Subterranean clover and low density grass and lucerne</td>
<td>4497 lb</td>
<td>3651 lb</td>
</tr>
</tbody>
</table>

TABLE II

Production in Terms of Dry Matter per Acre during First Full Season's Growth 1955-56 Season

<table>
<thead>
<tr>
<th>Component</th>
<th>1955-56 Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subterranean clover, low density grass, M. glutinosa</td>
<td>2225 lb</td>
</tr>
<tr>
<td>&quot; &quot; &quot; &quot; &quot; &quot; Rhizoma lucerne</td>
<td>2151 &quot;</td>
</tr>
<tr>
<td>&quot; &quot; &quot; &quot; &quot; &quot; Nomad lucerne</td>
<td>1865 &quot;</td>
</tr>
<tr>
<td>&quot; &quot; &quot; &quot; &quot; &quot; Marlborough lucerne</td>
<td>2189 &quot;</td>
</tr>
</tbody>
</table>

DISCUSSION

Mr Cummins, South Canterbury: You said these sub pastures could be used for flushing ewes. There is a belief, especially among farmers in our district, that sub. clover causes barrenness among ewes.
Professor Calder: The experience in New Zealand with Mt. Barker and Talarook sub. clover is that there is no evidence of sterility of grazing sheep on pastures of these species. We reared five generations of sheep on sub. clover and we did not find any effect on the fertility or the lambing percentage. The stock throve wonderfully well on sub. clover. An early strain of sub. clover developed in Western Australia, has been responsible for very marked degree of sterility in rams and ewes. We have heard of no such case in Canterbury. Mixtures of lucerne and sub. clover are what we advise for the flushing period.

A speaker: What are your reasons for sowing pasture in the spring? The young plants will have to survive the hot dry months. We can be sure of 100 per cent strike in the autumn and the plants have a better chance to develop.

Professor Calder: Spring sowings which include lucerne are best, on my own experience, on these light lands. If there is no lucerne in the mixture, sow in autumn. I have seen lucerne suppressed by clover and grass if sown in the autumn. We sow lucerne, sub. clover and grass at a time when all are going into the actively growing period and have equal chance of establishment. On the question of sowing going into drought period, we say sow early while there are still adequate supplies of moisture in the soil. The earlier the better; mid-September when there are adequate supplies of moisture. The soil dries off perhaps at the end of October but you have a good six weeks' growth to get the pasture established. September sowings have stood up to drought conditions during past two years remarkably well.

Mr Little, Hawarden: What about phalaris? Why didn't you use it in the mixtures?

Professor Calder: We have had 20 years' satisfactory experience here and at Ashley Dene. We could not get supplies of seed at the time. Then if obtainable the seed was 14/- a pound. We do not like to recommend a plant so expensive and difficult to obtain. You will see some phalaris at the Ashley Dene trial area. Besides being drought-resistant and nutritious, it is compatible with sub. clover. There have been complaints in some areas of phalaris staggers. We have had no trouble.

Mr Hunt, Cromwell: Regarding phalaris staggers: in Central Otago we have dry grass staggers, particularly in dry seasons. Are they the same?

Professor Calder: They are different. In the case of phalaris staggers they do not recover; they do recover from dry grass staggers.
The lighter soils of the Canterbury plains comprise about one million acres. There are several substantial areas of these soils well known to you. The Ashley Dene farm of the College is situated on one of them—the Burnham-Aylesbury area. Other well developed and much improved farms can be found throughout the various areas of the province. The performances of several of these have been written up and discussed at previous conferences.

The light soils of the plains are deficient mainly in lime, superphosphate, organic matter and water. These factors together with the past cultivation and cropping methods have not been productive of high-producing pastures and lucerne stands. It is only over the past 15 to 20 years that greater use has been made of lime, superphosphate and clover-based pastures. Lucerne is only now being developed, while the use of D.D.T. in grass grub control is quite a new aid to the maintenance of more permanent pasture production. Progressive farmers and the College farm at Ashley Dene, alike, have demonstrated that the light-plains soils of Canterbury are capable of a substantial increase in production.

The Ashley Dene farm of 878 acres carried the equivalent of 860 ewes in 1936, and this number only by the extensive use of the plough and considerable production of fodder and supplementary crops. By 1946 with improved subterranean clover pastures and a little lucerne; by liming and superphosphate topdressing; and with less cultivation it carried 1900 ewe equivalents (ewes, ewe hoggets, rams and killers equated to ewes). It is considered that with the extension of the lucerne area there is a further potential of 600 E E making a total of 2,500 E E.

Mr G. T. Askin, Ealing, Mid-Canterbury, in 1944 on his 1,183 acres carried 750 E E which by 1954 he had raised to 2,600 E E. Factors responsible were lime and superphosphate topdressing; full use of subterranean clover in pasture mixtures; and the establishment of 175 acres of lucerne. I had the privilege to inspect this farm during the summer of 1955-56 and would suggest that there is still a further potential of some 800 to 1,000 E E as the present policy of development with emphasis on lucerne is continued.

Mr E. C. Topp, Waipara, North Canterbury, developed his farm of 1,250 acres directly from inferior pasture into lucerne and is now growing 650 acres of lucerne which is limed and topdressed with superphosphate. In 1944 he carried 1,640 E E and in 1954 the figure was 2,950 E E. With a continuation of the present policy of topdressing and sowing 50 acres of lucerne annually it is expected that the property will carry over 3,700 E E. At least this is Mr Topp's belief which is confirmed by me after a visit to this farm in the drought of last summer.
Many other examples may be quoted but the above three were cited at last year's Conference and give authentic figures. These three performances may be summarised as follows:

**TABLE 1**

<table>
<thead>
<tr>
<th>Farmer</th>
<th>Area (Acres)</th>
<th>Ewe Equivalents at commencement of development</th>
<th>Carried after 10 years of development</th>
<th>At commencement of development</th>
<th>After 10 years of development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashley Dene</td>
<td>878</td>
<td>860</td>
<td>1,900</td>
<td>1.00</td>
<td>2.16</td>
</tr>
<tr>
<td>G. T. Askin</td>
<td>1,183</td>
<td>750</td>
<td>2,500</td>
<td>0.60</td>
<td>2.20</td>
</tr>
<tr>
<td>E. C. Topp</td>
<td>1,250</td>
<td>1,640</td>
<td>2,950</td>
<td>1.38</td>
<td>2.36</td>
</tr>
</tbody>
</table>

These figures confirm the general statement that, on average, light land farmed in the old style carried about three-quarters to one ewe per acre. They also show that by the adoption of new knowledge and methods this carrying capacity can be raised 125 to 150 per cent. It must not be forgotten that these three farms are still capable of significant further increases in carrying capacity estimated at half to three-quarters of a ewe per acre. Thus it seems possible to raise the old three-quarter-ewe light land to two and a quarter to two and a half ewes per acre and the old one-ewe light land to about three ewes per acre. Such carrying capacities on our light land 20 years ago were undreamed of.

A recent survey of farms in North Canterbury carried out and written up by M. Nelson, and summarised by H. E. Garrett for publishing shortly as a College Technical Publication, showed that the carrying capacity of the average light-land farm per 1,000 acres was:

**Sheep**

- 696 ewes
- 118 ewe hoggets
- 69 wether hoggets
- 61 wethers
- 15 rams

960 total as ewe equivalents = 896

**Cattle**

- 5.8

**Dairy cattle**

- 3.5

**Horses**

- 2.0

941

These average figures include well developed farms, and farms in various stages of development giving a ewe equivalent of 0.94 per acre, i.e., almost one ewe per acre.

The three farms quoted above increased production at, on average, better than ten per cent per annum in the first ten years after embarking upon a development policy, but thereafter according to Ashley Dene performances, the rate slowed up very considerably.

It is not expected that anything like all farmers will develop at what, on the evidence, seems to be the maximum rate. It is well recognised that there are limitations in individual skills and management as well as general hesitancy in the application of new knowledge and techniques, but even acknowledging these limitations it is suggested that there would be an annual average increase of at least three per cent. (In fact total sheep numbers for Canterbury for the years 1952-53 and 1953-54 have increased by six to seven per cent.)

Thus it can be expected that the light-plains land of Canterbury, even with the ups and downs of droughts, will for many years make a contribution to the increasing production of the province of about 30,000 ewes per annum. If we take the present carrying capacity—one million ewes on one million acres of light land—the evidence clearly shows that this figure can be raised to two and a quarter...
million ewes. Further it is expected by those competent to form an opinion that the figure might at some future date reach two and a half or even three million. Small-scale grazing areas, both at Ashley Dene and elsewhere, show that total annual production on average, even exceeds the requirements of three ewes per acre. We have only to learn on a wider and wider scale the importance of conservation of surplus growth for use in times of shortage; as well as the use by all farmers of lime, superphosphate, clover-based pastures, lucerne and D.D.T. In other words we know how to grow the extra herbage but we are still learning how to convert it into meat and wool.

It must be noted that the above potential of three million ewes is within our reach without irrigation water; but the irrigation of the Canterbury Plain is another story. Suffice it here to state that the application of irrigation water to these light lands has increased carrying to five ewes per acre on well managed irrigation farms. Further, on a 27-acre demonstration and experimental area at Winchmore under the Department of Agriculture, the carrying capacity is seven ewes per acre.

At today's prices and costs, development of light land as outlined, can be undertaken out of revenue, in an orderly and economic manner. Examination of farmers' accounts and our own experience at Ashley Dene show this to be the case. In fact, rates of increase considerably greater than our suggested three per cent can be financed out of income. Is it too much to expect these faster increases? We have the knowledge and the economic climate is still favourable. Such development is to the benefit and satisfaction of the individual occupier and the community alike.

DISCUSSION

Mr Butcher, Broadfield: With increased production resulting from grass and lucerne, Professor Flay did not mention fencing.

Associate Professor Flay: At Ashley Dene as soon as we developed the pasture we were involved in further subdivision and water reticulation. These call for capital expenditure. The important point is this, development is done out of income.

Question: Has Professor Flay warned the companies — lime, fertiliser and freezing works regarding the need to prepare for increased output?

Associate Professor Flay: There is more need in Southland and Marlborough. In Canterbury we have the lime but cannot get enough superphosphate. We do have to rely on the commercial world; if they will not do it then farmers must.

Mr Polhill, Geraldine: With the increased carrying capacity on lighter land in Canterbury what is the fear in health of sheep?

Associate Professor Flay: From the practical farm management point of view our stock are in excellent condition.

Question: Has anyone had any experience of irrigating subterranean clover?

Mr Hurst, Papakaio: On the experimental farm in North Otago, we had excellent results by irrigating subterranean clover and lucerne and subterranean clover and ryegrass in October.
WATER DEFICIENCY

T. W. Walker, Lincoln College.

All plants must have water if they are to grow, and whilst a fresh green plant contains about 80 per cent water, this is only a small fraction of the amount it takes up from the soil. Most of the water a plant takes up, is lost by transpiration of vapour through the stomata which are small structural openings in the leaf. H. L. Penman of Rothamsted Experimental Station in England has been studying the factors which affect the amount of water transpired by plants. The application of his ideas, still not fully developed, to the situation in New Zealand and particularly in Canterbury, are of some considerable interest, not only because they explain current practices and features of our farming, but because they have been developed from fundamental principles and can be applied to one of the most important future problems in Canterbury—irrigation.

Evaporation and Transpiration

Consider first the evaporation of water from a lake or pond or from an evaporimeter as used at meteorological stations. The factors which cause water to be evaporated are wind, temperature, humidity, and hours of sunshine. All these can be measured, and the amount of water evaporated from an open-water surface can be calculated (with a fair degree of accuracy) merely from meteorological data. For instance the calculated figure at Lincoln is on the average 34 inches a year, whereas the observed figure (average for ten years or so) is 36 inches. This means for example that if no rain or water entered Lake Ellesmere the level would drop by about three feet in a year. However, with an average annual rainfall of about 26 inches, even if no other water but rain entered the lake, the level would fall by only about ten inches.

In the case of plants, exactly the same meteorological factors affect the amount of water transpired, at least when there is no shortage of water, with one important difference, namely that the stomata may close at night and may impede the flow of vapour even during daylight. Penman has shown that pastures growing with adequate supplies of water, transpired less during the year than was lost from a nearby open tank, but there was a close relationship between the amounts which transpired and evaporated which varied a little with the season. During the summer, the pasture transpired about 80 per cent of the amount of water lost by evaporation from an open tank; for winter the figure was 60 per cent, and during spring and autumn about 70 per cent.

The important point about these observations is this: if we know how much water is being evaporated from an open water surface in a given region (and it can even be calculated if enough weather data are available), we can calculate how much water a pasture would transpire, if it were never short of water and there were no bare spaces in the sward. This is called the "potential transpiration" because naturally if the pasture becomes short of water, it will begin to wilt, leaves will wither, growth will be reduced and transpiration will be much less than if the pasture were in full vigour—indeed the death and shedding of leaves is the plant's mechanism for reducing transpiration. This all means that potential transpiration is gov-
Fig. 1.
erned primarily by the weather and we can calculate approximately just how much water a pasture needs for transpiration if a shortage of water is not to limit production of dry matter.

**Application to Pasture Production**

The picture can be clarified by reference to the actual situation at Lincoln shown in figure 1, which shows the average monthly rainfall and potential transpiration (called potential evapo-transpiration in the figure). The rainfall is seen to be fairly evenly spread throughout the year giving a total of about 26 inches. At a point in early October, transpiration begins to exceed rainfall, and if the plants could obtain no stored-up soil moisture, growth would begin to suffer. It is not until mid-April that rainfall again begins to exceed potential transpiration, and between these two dates, a pasture would need about ten inches more water than is supplied by rain if it is not to drop in production. For example in January, transpiration by a vigorously growing pasture would be about five inches of water on the average, whereas the average rainfall in January is only two inches. If the pasture is completely browned off by January, this two inches of rainfall might be completely wasted because it falls on the dead leaves and bare soil and may be evaporated from the soil surface without giving any extra plant growth at all.

Some of the deficit of ten inches of water can be made good by the pasture plants drawing on soil moisture reserves, and this is of course a very variable figure depending on the type of soil and the depth of plant rooting. In figure 1 it has been suggested that the soil may supply four inches of water, but this would probably only apply to deep heavy soils, as only a heavy soil where roots penetrated to at least 18 inches could supply four inches of available water. On many light plains soils it is doubtful if the soil could supply more than one inch of water. Lucerne of course, on soils where it can root deeply, draws on a bigger volume of soil and obtains water from lower depths not reached by shallow-rooted plants. If a soil with a suitably high water table could supply ten inches of water, there would be no limitation of growth due to a shortage of water, but if we assume that under average conditions a soil could supply two inches of available water to a pasture, there would be a shortage of eight inches for maximum dry matter production. On the average from the end of November until the end of April, production will normally suffer due to water shortage, and will depend greatly on rainfall.

From mid-April to October, rainfall exceeds transpiration and the first few inches of excess rainfall is absorbed by the soil until it is saturated with water. Further rain during the winter then drains away as surplus water.

It is the high figures for potential transpiration directly related to weather conditions which are responsible for the dried-out pastures and low production during the summer in areas such as Canterbury. In a hot north-west wind a pasture may transpire between a quarter and a half inch of water a day, i.e., equivalent to a gentle drizzle, invisible of course because of the high temperature, low humidity and the wind. In Westland, even if transpiration were as high as in Canterbury, the average rainfall in January for example exceeds six inches at all the weather stations, and only in a much drier year than average would a shortage of water limit pasture production. The main problem there is excess water causing poor drainage and intense leaching of the soil. A graph similar to that for Lincoln would show the rainfall curve lying above the transpiration curve for all months of the year.

It is of interest that average annual figures for dry matter production measured by C. E. Iversen on pastures at Lincoln show a
MONTHLY RAINFALL and CALCULATED TRANSPIRATION at LINCOLN 1955-1956

Soil moisture surplus or recharge

Potential evapo-transpiration

About 12" deficiency

4" soil moisture utilisation

Rainfall
spring peak during November after the utilisation of about two inches of soil moisture; thereafter production slumps badly and frequently there is no autumn flush even though there is adequate water, because by this time the temperature may be too low to enable pasture plants to make much growth. There is no question that with proper pasture species and management and with adequate water the production curve for dry matter could be smoothed out to avoid excessive peaks and slumps during the growing season. Ideally if maximum use is to be made of summer temperatures and sunlight, production curves should closely follow the potential transpiration curve.

As the 1955-56 season has been one of the driest of this century, it is perhaps profitable to examine comparable data for this season with the average data presented in figure 1. This can only be done to the end of April as shown in figure 2. Now in June 1955 we had nearly five inches of rain and less than one and a half inches transpiration and similar figures were obtained in July. This means that rainfall exceeded transpiration in these months by about six inches and all the soils on the College farm were all saturated with moisture until some time during August. From then on, rainfall was considerably below average, only about eight inches being recorded from the end of July to the end of February compared with the average of 14 inches. The calculated potential transpiration was similar in 1955-56 to the calculated average, and the drought conditions were due entirely to low rainfall during the spring and summer periods. As seen in figure 1, potential transpiration exceeds rainfall by about ten inches on the average, while during this past season it exceeded rainfall by about 15 inches. Even with 100 per cent efficiency in its use, almost eight inches of irrigation water would have been needed during January and February alone, and for the whole season, assuming as in figure 1 that the best soils could supply four inches of water, the deficiency would have been 11 inches compared with the average of six inches. In other words farmers irrigating their soils needed about twice as much water this year as in an average year.

Application to Cropping

Some traditional farming practices in Canterbury can be explained by reference to figure 1. Indeed it explains the nature of the original vegetative cover of tussock, because in all regions of the world where there is such a deficit of moisture during the summer months, grasses are much more able to survive the climatic conditions than are trees. Cropping with annuals is also common in such areas. In the case of wheat, for example, autumn-sown wheat is sown about May and is well-established and has made considerable growth by October when transpiration begins to exceed rainfall. On the heavier soils capable of supplying four inches of water to the wheat crop, growth should normally proceed unhampered by a shortage of water until the crop matures in January. On lighter soils a shortage of water will limit yields except in a wetter year than average, because reserve soil moisture will have been used earlier. Spring-sown wheat sown in September and harvested in February will be a much more risky proposition than winter wheat even on the heavier soils, because it will run into a period of moisture deficit sooner than autumn wheat and mature later. In Southland on the other hand where the moisture deficit is much less, spring-sown wheat may do as well as autumn-sown wheat.

Much less water is lost by evaporation from a bare soil than a cropped soil, particularly if care is taken to keep a fine layer of soil on the surface which acts as a mulch. By fallowing during the summer months much of the reserve soil moisture can be retained in the soil to help meet the needs of pastures sown in late summer and autumn.
A shortage of water commonly reduces the yields of such crops as potatoes which are normally growing during the period of moisture stress.

Application to Irrigation

It has been shown at Lincoln that potential transpiration exceeds rainfall by ten inches on the average. Soils may supply from about one to four inches depending on the type of soil and the nature of the crop. This means that for maximum production some six to nine inches of irrigation must be applied in such a way that it is all used by the plants. As the efficiency of application of irrigation water is much less than 100 per cent, due to losses by run-off, the rough cracks in the soil, and the draining away of applications in excess of the water holding capacity of the soil considerably more than these quantities may be needed in practice.

From current weather data it is possible to calculate potential transpiration rates for weekly or longer periods, and knowing the rainfall over the same period, a chart can be kept each season, which will show when transpiration begins to exceed rainfall. It would need a little experience on individual soils and crops to decide just how much water the soil could supply before growth began to suffer, but if this were about two inches, then as soon as transpiration exceeds rainfall by two inches, irrigation should begin. This would be during November on the average at Lincoln, but could be earlier in a dry year or later in a wet one. The amount of water and frequency of application would vary from soil to soil, but in the example chosen, the soil would need two inches to bring it back to field capacity. On light soils which could supply one inch of water before growth was reduced, it might be wasteful to irrigate with more than an inch, as the excess would only drain away; such soils would need frequent light applications of water, in contrast to the heavier soils which could get heavier less frequent applications.

In England this sort of weather data is computed by the Air Ministry, and during the summer, advice on the regional deficit of water is broadcast weekly. According to the crop he is growing and the type of soil (although little emphasis has been placed on the latter in England), a farmer or market gardener knows just when he should irrigate. Similar calculations could be made in New Zealand, but more experimental work is needed to test these ideas under our own conditions.

This approach is not very helpful in a system of border-dyke irrigation where a farmer can use water only at a set time. This system may be wasteful of water and whilst this is perhaps not important when very little land is irrigated, it will become more and more necessary to use water efficiently as the irrigated acreage increases. It is not too early to begin thinking of ways of increasing the efficiency of irrigation, and Penman's ideas give us a sound basis on which to build. If Canterbury is to prosper there is no question that irrigation must be practised on a wide scale to double or even treble production on some soils. Certainly the economics of irrigation need careful consideration, but land is not being farmed efficiently if water is needed and if abundant supplies are close at hand and running out to sea.

DISCUSSION

Mr Homersham, Christchurch: Could Dr Walker tell us the relative values of water available to plants from the basic soil types?

Professor Walker: I cannot answer accurately at all. There is a very big difference in moisture capacity between heavy soils and light. But heavy soil hangs on to water much more tenaciously and
we can find soils which hold very much more moisture than a lighter soil which actually supply less water to plants. The question of trying to measure just how much water in the soil is available to plants is a very difficult one. Laboratory tests are very difficult to interpret in the field. The whole question is affected by differences in soil structure and the rooting depths of different plants. I cannot give you a figure for any soils. In the particular approach I covered this morning I tried to get over the business of measuring soil moisture at all by noting transpiration and rainfall. If you know just how much water you can allow to be taken from the soil without the plants suffering, there is no need to know the moisture retention at all.

Mr Hurst, Papakaio: I have been irrigating for about 30 years. Every year, except one year when we had 39 inches of rainfall, we had to put on water. With border dyking you cannot put on less than five inches of water. At Winchmore they had to water every week and were putting on five inches every week. Yet all Dr Walker says we need for the year is ten inches. He says the efficiency of border dyking is only ten per cent. Ask any farmer who has done any irrigating at all; he’ll tell you the ground is getting more than ten per cent of the water. It is getting the whole lot.

Professor Walker: I did say that the border dyking system is grossly inefficient. My figure of ten per cent is possibly an under-statement. It may be 20 per cent efficient. When you say you apply five inches a week by border dyke irrigation, you have no clue as to how much of the water is still held. The soil possibly only holds one inch; therefore four inches drains away. Therefore you are wasting four inches—which is only 20 per cent efficient.

Mr Hurst, Papakaio: Have you any practical experience of irrigating? If you irrigate a paddock and put on five inches of water and dig down you’ll find the water has only gone down four and a half inches; after that the soil is dry. Where has it gone to?

Professor Walker: You will find cracks in the soil if you look hard enough.

Mr McKenzie, Southland: What do you think about the amount of humus in relation to how the ground holds water? Mr Hurst is a long way from Southland and has only got sand underneath. Is the amount of water retained by the soil and made available to the plants governed by the amount of humus in the soil?

Professor Walker: The humus content of the soil is a very important factor in deciding the amount of water soil can hold. Take the extreme case of peat; it will hold more than its own volume of water. It may contain 50 per cent of moisture which may not be available to plants, and the plants may wilt. The humus content improves the soil structure and improves the moisture holding capacity of the soil.

Mr Butcher, Broadfield: What is the best way for us to gauge how much water to put on with spray irrigation? We do know the amount of rainfall; we are not sure of the amount of evaporation. Would a glass jar of water give any indication of the amount of evaporation to guide our spray irrigation?

Professor Walker: I would not like to see farmers trying to judge how much water lost by evaporation by using a glass jar. I should think it ought to be possible in Canterbury, and New Zealand, for people to be able to calculate from readings from the Meteorological station at this College. Even that would mean modifying in the light of experimental work. There may be only 75 per cent efficiency in spray irrigation. We may say that four inches is needed in January because of evaporation but you might need rather more than that because of only 75 per cent efficiency.
UNDERGROUND WATER SUPPLIES FOR IRRIGATION


INTRODUCTION

The discovery that water could sometimes be obtained by means of holes dug in the ground has been compared in its importance to the human race with the discovery of the use of fire. It was through this discovery of ground water that human occupation of the land was able to spread far from the neighbourhood of supplies of surface water such as rivers, streams, lakes, and springs, on to the vast waterless plains and plateaux that provided pasturage for stock and soil for the raising of food crops, and even into the hill country of arid and sub-arid regions where surface water supplies are meagre and unreliable. And this was accomplished without the necessity to build expensive aqueducts to carry water from perennial sources, though of course these were constructed by the ancient civilizations to supply cities that grew in size beyond the capacity of local water sources.

The importance of ground water from very early in human history is attested by the frequent references to wells and springs in the Bible (especially the Old Testament) and other early literature, and by the remains of ancient irrigation systems supplied by means of wells and tunnels in many parts of the Middle East, for example the kanats of Persia. Underground water has throughout history retained its importance to human activity, especially in the field of agriculture, and its value as a source of irrigation water in New Zealand, already very considerable, seems likely to increase.

Advantages of Ground Water

Ground water may be the only supply available locally in some areas, but even where surface water is obtainable, water derived from wells may possess distinct advantages, some of which are as follows:

(1) It is generally **free from suspended matter**, and is clear and sparkling without filtration. This is in marked contrast to water derived from rivers and streams, many of which in time of flood provide only muddy water, as is well known to their cost and inconvenience by many farmers dependent on water races in Canterbury and elsewhere.

(2) Its **chemical composition** over long periods is generally much more uniform than that of water derived from surface sources (with the exception of rain water and water impounded by small dams in the head waters of streams in insoluble rocks). Rivers subject to great variations in flow vary greatly in composition from one season to another, having a much higher concentration of dissolved minerals during dry periods than when swollen by recent rains.

(3) Its **temperature** is practically constant throughout the year—much lower than surface water in summer and higher in winter. Water from wells more than about 30 feet deep seldom varies more than two or three degrees Fahrenheit. Water from depths between 30 and 100 feet usually has **about the same temperature** as the mean annual air temperature of the locality—about 55 or
56 degrees Fahrenheit in the neighborhood of Christchurch. For
deeper waters the temperature may be expected to rise only
about one degree Fahrenheit for every 50 to 100 feet increase in
depth. Ground water is therefore much more efficient for
cooling in summer, and this is of especial importance to industries
and dairy farmers.

(4) A ground-water supply is generally more dependable than a sur-
face supply in times of drought. After a few days or weeks
without rain many surface streams are dry, but, provided a well
is deep enough, ground water is always available year in and
year out. Even shallow wells are less rapidly affected by drought
than all but the largest rivers, as has been amply demonstrated
by the recent drought in Canterbury and other parts of the South
Island, when well supplies continued to provide adequate water
while the soils of the province were parched and many large
streams dwindled to mere trickles or went completely dry.

(5) From the health aspect ground water is generally safer than sur-
face water. If a well is properly located and constructed the
water derived from it is much less likely than surface water to
be contaminated or polluted. Water-bearing rocks act as very
efficient filters, straining out harmful bacteria and other solid
matter, and obviating the necessity for expensive chlorination and
filtration plants.

(6) A well is often the cheapest and most convenient source of water
for domestic, industrial, municipal, and farm use. All the equip-
ment involved is on the spot under the eye of the user and on his
own property; the often considerable expense of long pipe-lines,
large reservoirs, and expensive head works such as weirs and
dams, can frequently be avoided; and generally a whole water-
supply scheme can be constructed and put into operation more
quickly by means of a well than by any other method. Legal
problems involving access through land of different ownership
and the complicated matters of water rights are generally voided.

Some of these advantages are of more significance to industries
and communities than to farmers concerned with irrigation supplies,
where quality of water is of secondary importance to quantity, but
nevertheless ground water possesses in many cases distinct advantages
over other supplies even for irrigation. In many places it is the
only source readily available, and in nearly all places it is at least
worth consideration.

One of its disadvantages is the relatively low temperature of
ground water in summer as compared with surface water, which may
tend to hinder plant growth; but where it is sprayed through the air
in fine droplets, as in most sprinkler irrigation schemes, it quickly
warms up to the air temperature. Another disadvantage is the risk
involved in sinking a well in some areas where insufficient informa-
tion is available to indicate whether adequate quantities of water can
be obtained. In such areas, where a competent geologist considers
the chances are favourable, farmers should be more willing to spend
money on a test well (as is commonly done overseas), and not blame
the geologist if the well turns out a failure. After all a well is only
part—often only a small part—of the total expense of an irrigation
scheme. The expense of a test well or other type of investigation
should be regarded in the nature of insurance.

Source and Occurrence of Ground Water

Nearly all ground water is derived more or less directly from
the rain. Only small quantities are supplied in other ways, and
then only in limited areas. In some geological formations that have
been deposited under the sea and then uplifted to form land, some
of the water may be sea-water originally buried with the sand and mud that collected on the sea-floor. A part of the water (and most of the heat) of many hot springs is supplied by the emanation of steam from molten rock perhaps far below the surface. All other ground water has its source in water that has fallen on the ground surface in the form of rain, hail, or snow, perhaps at some distance from the well or spring that eventually returns it to the surface, but more frequently in the same general locality.

Part of the rain that falls on the soil may run off immediately, especially in hilly country composed of impermeable rocks, forming rills and streams that may unite to form rivers and flow out to sea. A part, however, percolates into the soil; and on gently-sloping or flat land, especially if the soil and underlying rocks are permeable, this may be the greater part of all the total precipitation. Of this water that enters the ground, some remains in the upper layer of soil, but once the soil has absorbed all the water it can hold, the excess begins to percolate further downwards where it contributes to the body of ground water. The water that remains in the soil layer may be taken up by the roots of plants, a small proportion being incorporated into the new growth of plant material, but by far the greater part being transpired by the leaves into the atmosphere. Part, also, is evaporated directly into the air from the soil surface. A further part may move laterally more or less rapidly through the permeable upper layers of soil and contribute to the flow of streams.

That part of the precipitation that has percolated through the soil and beyond the reach of plant roots and atmospheric evaporation eventually reaches the water table—the upper surface of what is known as the zone of saturation—below which all permeable rocks are saturated with water. This is the water that supplies springs and wells, and is properly called ground water. The water level in shallow wells (neglecting for the moment artesian wells and other deep wells that penetrate to layers of water-bearing material underlying impermeable layers) is an indication of the level of the water table. (Figure 1.)

In a narrow zone (a few inches to a few feet in thickness) above the water table, some water is usually held by capillary forces; this is known as the capillary fringe. Where the water table is very close to the surface, the capillary fringe may extend upwards to the soil and supply a significant part of the soil moisture. The water in this zone, however, will not flow into wells.

The depth to the water table varies greatly from place to place. It is at sea-level near the coast and rises gradually inland. It is generally close to the surface under valleys carrying permanent streams, but is further from the surface under ridges and high ground, though generally (in humid areas) at a greater altitude than the river level. The shape of the water table is in fact what has been called a subdued replica of the ground surface. (Figure 2.)

All ground water is moving down the slope of the water table towards the surface streams and the coast. Its rate of movement is incomparably slower than that of surface water, being of the order of a few feet to a few hundred feet a day, depending on the permeability of the material through which it has to percolate. In spite of this very low rate of movement, because of the wide extent of ground water the total quantity available is very great. It has been calculated that in the area of Canterbury between the Waimakariri and Selwyn rivers, the flow of ground water amounts to 45,000 million gallons a year, or about 500 gallons a day for each person living in this area.

In some parts of the country the rocks vary greatly in permeability, and layers of impermeable material through which water
Fig. 1—Underground Water Zones (direction of water movement shown by arrows.)
Well A is a good well, since it ends in a permeable bed below the water table.
Well B is a poor well (if tightly cased), since it ends in a bed of low permeability. It should be blown off above the bed of silt or clay, or carried deeper into the underlying gravel.
cannot percolate occur interbedded with permeable formations. In such areas conditions may be favourable for the occurrence of artesian wells, in which the water in deeper water-bearing layers will rise to and above the ground surface of its own accord, due to the hydrostatic pressure in the artesian stratum. This occurs where ground water moving laterally becomes trapped under an impervious confining bed and builds up pressure in the water-bearing stratum due to the head of water in the same bed further back up country at higher levels. The seaward parts of the Canterbury Plains have such a favourable geological structure, and artesian wells are common in the Christchurch area and a few also exist on Levels Plain and near Ashburton. In other places the pressure in deep layers is not sufficient to raise the water above the ground surface but may raise it above the water table. In still other areas, due to the nature of the rocks and the geological structure, the water levels in wells tapping deeper aquifers (or water-bearing beds) may be lower than the water table or the water level in shallower wells.

Water-bearing Deposits in New Zealand

The geological formations of which New Zealand is composed vary greatly in their water-bearing properties. (Figure 4.) Generally speaking, the older rocks forming the main mountain ranges of both islands and the adjacent hilly country are hard and relatively impermeable. They have been consolidated by pressure and their pore spaces reduced or entirely eliminated by compaction or cementation (the deposition of cementing minerals such as lime, silica, and iron compounds). Where they have been fractured by earth movements, joints and faults may provide passages for water, but generally the yields from wells in these rocks may be expected to be small and inadequate for irrigation supplies, though they may be sufficient for stock or domestic use.

The younger sandstones and limestones of the hilly country of many areas of New Zealand also generally yield only small supplies. The porosity of these rocks is greater than that of the older hard rocks, but the pore spaces are commonly so small that the permeability of these beds is too low to allow free movement of water. For the production of water from wells, permeability is of greater importance than mere porosity. Permeability (or the ability to transmit water) depends on the size of and degree of interconnection between the pore spaces in a rock or other material, while porosity is the ratio of the total volume of the pore spaces to the volume of the rock. Clay, for example, may have a porosity of as much as 50 per cent, but the pores are so small that its permeability is so low that wells sunk into clay are almost useless. Some limestones, however, are sufficiently hard to have developed and to support open joints that may carry water; and such joints may become enlarged through solution into channels carrying veritable streams. A well in limestone that happens to penetrate such a solution channel may yield copious amounts of water. Generally, however, our Tertiary marine rocks (sandstones, mudstones or papa, and limestones) are not favourable sources of water for irrigation supplies.

The volcanic rocks that occur in numerous scattered localities throughout New Zealand (e.g., Banks Peninsula, Otago Peninsula, the Auckland district, Mt. Egmont, and much of the central district of the North Island) differ greatly in their water-bearing properties. In some places joints and permeable zones in these rocks provide adequate passages for water, and well yields may be quite high, as in the basaltic rocks near Auckland and some of the rhyolites in the Rotorua district. Banks Peninsula has not yet been adequately tested by a
sufficient number of deep wells for its potentialities to be known, but
the indications are that well yields are likely to be small.

By far the most important sources of ground water in this coun-
try are the deposits of sand and gravel laid down by rivers in very
late geological times. These deposits underlie the alluvial plains and
basins in both islands and also extend, in many places as terraces,
far up the main valleys into the mountains. It is largely to the
intense erosion of the hard rocks of our mountain areas during the
Glacial Period or Ice Age that we owe these useful deposits, but some
are still being formed under present conditions. Some of our down-
lands are formed of gravel deposits of somewhat greater age and are
also water-bearing, but as a general rule the older the gravels the
more their permeability has been reduced by compaction and weather-
ing with the formation of clay that tends to fill up their pore spaces
and hinder the flow of water. It is for this reason that the most
prolific wells are commonly found in the youngest alluvial deposits
adjacent to the present river courses.

The material laid down by rivers in the past, like that to be seen
at the present time in river-beds, consists not only of gravel but also
of sand, silt, and clay, and of various mixtures of these ingredients.
The various beds of gravel, sand, and silt interfinger in a complicated
manner, both vertically and horizontally, as do the sand and gravel
bars in present river-beds, and so it is generally quite impossible to
predict accurately the exact depth of well required at any particular
site. For high-yielding wells, as required for irrigation, it is necessary
to find a clean gravel bed of high permeability, where a minimum of
fine sand and silt has been laid down with the gravel. The action of
streams during transport of the detritus from the mountain areas
accomplishes a sorting process, and so generally the best wells are to
be found in the lower parts of valleys or further out on the alluvial
plains, where stream action has had more time and a greater oppor-
tunity to sort out the materials into various grades. For example,
although the greater part of the material underlying the Canterbury
Plains for depths of many hundreds of feet is generally permeable,
and satisfactory wells can usually be obtained in any part of the
plains, the highest-yielding wells occur near the coast, especially in
the districts around Christchurch. Here beds of clean "running
shingle" exist, interbedded with silts and sands free from pebbles, and
yield water at rates of up to 1000 gallons a minute from wells less
than a foot in diameter. Higher up the plains the gravel is generally
mixed with fine sand and silt and hence is of lower permeability, and
in, for example, the Oxford and Springfield districts a yield of 1000
gallons an hour may be considered about average.

The younger gravel underlying lower terraces near the rivers is
in general looser and more permeable than the older gravels at high
levels. For this reason better wells exist near the rivers—as for
example on the lower terraces near the Rakaia and Waikariri
rivers—than on the plains themselves midway between the rivers.
This principle also applies to most Canterbury rivers both north and
south of the plains, and probably generally throughout New Zealand.
Nevertheless, wells with yields high enough for irrigation can often
be constructed in areas at a considerable distance from the rivers and
in the upper parts of the Canterbury Plains, especially if special
methods are adopted to increase their yield. Where single wells cannot
be induced to yield a sufficient supply, there is no reason (apart from
expense) why several wells should not be sunk a chain or so apart,
and if possible pumped as a group. Such batteries of wells are com-
monly used overseas.
The first essential for a successful well is that it must penetrate below the water table. Although the water table is close to the surface in some places—e.g., on valley floors occupied by a permanent stream that is not entrenched far below the surface, and on the coastal fringes of plains descending gently to sea-level, as immediately to the north and south of Banks Peninsula, and in the Seadown district of Levels Plain near Timaru—in other areas the water table may be up to 100 or 200 feet below the surface. There are parts of the Canterbury Plains where the depth to the water table is 100 feet or more; the central parts of Ashburton County, from near Chertsey to Methven, for instance, and in the districts around Kirwee and Darfield. No water can be obtained by means of wells from the unsaturated material above the water table, although this may be quite permeable and water may percolate through it from the surface.

A second requirement is that the well must penetrate a sufficiently permeable saturated bed to yield a quantity of water sufficient for the purpose for which it is sunk. In a great many parts of New Zealand—probably over the greater part of the settled area—wells yielding a few hundred gallons an hour may readily be sunk, but high-yielding wells suitable for irrigation can be constructed only in certain areas that are underlain by rocks of at least a certain minimum permeability. Neglecting the possibility that some wells in hard rocks may chance to strike a very open water-bearing joint or joint system, or (in limestone) a solution channel, or (in volcanic rocks) a lava tunnel carrying water—possibilities that cannot usually yet be predicted with any reasonable degree of assurance—for all practical purposes the only satisfactory water-bearing formation for irrigation wells is geologically young alluvium containing gravel or sand beds. Even with this restriction, however, the potential area where ground-water irrigation could be practised is very large, including as it does all the major plains of the country together with many of the valley floors and terraces.

The yield of a well depends on many factors, but the most important is undoubtedly the permeability of the material into which it is sunk. Other factors influencing yield include: the thickness of the water-bearing stratum, the depth of penetration of the well into the water-bearing stratum, the type and diameter of the well, its condition, and of course the capacity and efficiency of the pump. Much could be written about each of these various influencing factors, but space allows only the following brief statements. Other things being equal in each case, the following relations are found to be true:

1. The thicker the water-bearing stratum the greater the possible yield.
2. The greatest possible yield is obtained when the well penetrates to the bottom of the water-bearing stratum.
3. Greater yields are obtained from wells with adequate openings through the casing than from solidly-cased wells open only at the bottom. The maximum yield is obtained from wells with the casing or lining perforated or slotted throughout the entire thickness of the water-bearing bed, or in which special well screens have been installed and the solid casing withdrawn to near the top of the screen.
4. Development improves the yield of many wells, and may even double the yield obtained without such treatment. Development involves the removal of fine material from the spaces between the larger fragments of the formation around the well, by means of surging, back-washing, and over-pumping, either with com-
pressed air or with special well-drilling equipment. Some drillers in New Zealand are now adopting modern methods of development that have been in use overseas for several years, and this practice is to be encouraged. Time and money spent on proper development of drilled wells in alluvial formations is well worth while. The purpose of development is to increase the permeability of the water-bearing formation in a zone around the well screen, and in effect it increases the diameter of the well and reduces friction losses in the water flow towards the well.

(5) Increase in diameter of a well does not increase the yield as much as is generally believed. The increase in yield is nowhere near in proportion to the increase in diameter, much less in proportion to the increase in cross-sectional area (which increases as the square of the diameter). In actual fact it has been found in practice (and can be substantiated in theory) that the yield increases only from 15 per cent to 30 per cent with a twofold increase in diameter. Thus a well 12 inches in diameter may be expected to have a yield only about one-fifth larger than a six-inch well. It is necessary only to have a well large enough to take the pump it is desired to install. The advantages of dug wells of diameters of three feet or more lie in their storage capacity rather than in their increased yield. With very large wells, such as pits excavated by bulldozer or dragline, other factors enter and this relation between diameter and yield no longer holds.

(6) Friction losses in the well itself become important only in very deep (100 feet or more) wells of small diameter when they are pumped at high rates.

(7) Wells that have become silted up with sand or silt, or whose screen openings, slots, or perforations have become clogged with clay or mineral deposits, naturally fall off in yield. The casings of some old wells of small diameter have become so encrusted with iron deposits that the diameter is considerably reduced and the flow of water significantly obstructed. Obviously a well cannot perform satisfactorily under such conditions any more than a domestic water system in the same state, and like the latter the well should be cleaned out or replaced.

(8) Finally, the yield of many wells is limited to the capacity of the pump installed. To obtain the maximum yield from any well, the pump must be of such a capacity and so placed in the well that the well water level when pumping is drawn down to close to the bottom of the well. This involves the question of the hydraulics of wells, which is briefly discussed in the next section.

Under this heading, however, the various types of wells must be considered. At the present time drilled wells are the most common and frequently the cheapest type for use in alluvial formations where the depth is greater than about 30 feet. For wells up to about 30 feet deep in unconsolidated alluvium without large stones pipes up to about three inches in diameter fitted with drive-points may frequently be driven with a maul or monkey. Occasionally open-ended pipes can be direct-driven. Driven wells are not, however, generally suitable for irrigation wells, owing to their small diameter and limited depth.

Where the water table is close to the surface and permeable deposits exist immediately below it, dug wells may be satisfactory. These may be excavated by hand or by orange-peel or clam-shell bucket, and lined with bricks, wood, or concrete pipes. Pits excavated by bulldozer or dragline are also satisfactory and cheap to construct where conditions are suitable—high water table and loose unconsolidated material. One of the great advantages of large diameter wells or pits is their storage capacity, which in the case of a well four feet
in diameter amounts to 80 gallons per foot in depth. A 12-foot well in which the water is 15 feet deep holds just over 10,000 gallons. Hence such wells can be pumped intermittently at high rates for short periods. Their sustained yield, however, is frequently not much greater than a drilled well of the same depth—generally not more than twice as great. Dug wells (using the term in the broad sense to include pits) may be more satisfactory than other types in areas where the permeability of the water-bearing material is not very high and where the water table is within a few feet of the ground surface.

Drilled wells of about six inches diameter are the most common type of irrigation well, and in alluvial deposits are generally drilled by the percussion method and cased with wellpipe. For maximum efficiency the well should be adequately developed as previously mentioned and fitted with a screen or section of perforated or slotted casing to allow free entry for the water.

HYDRAULICS OF WELLS AND PUMPS

This subject can be discussed only briefly here, but is of prime importance in the understanding of the performance of wells. (Figure 3.) When a well is pumped its water level is lowered, rapidly at first and then at an ever-decreasing rate until (with a constant rate of pumping) it becomes sensibly stationary. A cone of depression forms in the water table around the well, the water surface sloping down from all sides towards the well. In this way the ground water is diverted from its normal course and caused to flow towards the well to supply the pump. For any constant rate of pumping a state of equilibrium is reached when the hydraulic gradient (slope of the surface of the cone of depression) induced by the lowering of the water level in the well is just sufficient to cause water to flow into the well at the same rate as it is being abstracted. The amount of lowering of the well water level is known as the drawdown. The normal water level in a well before pumping begins is known as the static or rest level; during pumping the well assumes a pumping or working level. The drawdown is the difference between the static and pumping levels. For wells in very permeable materials pumped at only low rates (a few hundred gallons an hour) the drawdown may be so small that it can barely be measured: it must nevertheless be present, or there could be no flow of water into the well. In some wells in materials of low permeability (e.g., dug wells in the clayey brown gravels of the downlands of Canterbury) the water level never reaches its equilibrium pumping level, because the wells are pumped dry before the equilibrium drawdown is attained. When pumping ceases the water level in a well rises, rapidly at first and then more and more slowly until it finally recovers its original position.

It is found that there is generally a simple relation between yield and drawdown for any particular well, and for wells of the same type, diameter, and depth in material of the same permeability: the yield varies directly with the drawdown. Thus if a well yields 100 gallons a minute with a drawdown of 10 feet, it will be capable of yielding 200 gallons a minute when the drawdown is 20 feet, and with a drawdown of only five feet it will yield 50 gallons a minute. The number of gallons a minute produced by a well per foot of drawdown is defined as the specific capacity of a well, and this property provides a convenient method of comparing the productivity of wells and water-bearing materials. The specific capacity of the hypothetical well discussed is 100 divided by 10, that is 10. This figure is reasonably constant for any particular well, and also, where conditions are uniform, for all wells tapping the same water-bearing bed in the same area. The specific capacities of wells on the Canterbury Plains vary from about 400 at Rangiora to about four at Weedons, and probably
Fig. 3—Section Through Well and Water Table.
Specific Capacity = Yield divided by Drawdown (approx. constant for any one well.)
lower in some areas further inland. In the Christchurch area specific capacities are generally between 20 and 100. Wells in the older gravel of the downs have specific capacities of less than one.

Because of the fact that the water level in a well is lowered by pumping, the static level alone is not sufficient information on which to base the design of a pumping unit for an irrigation well. Some idea of the drawdown at the required pumping rate is necessary before the type of pump suitable for the job can be decided on. For example, the static level may be well within reach of a centrifugal pump at the surface, but the drawdown at the desired yield may be so great that the pump breaks suction before the discharge is sufficient. Adequate pumping tests to determine drawdown and yield are essential in many areas where information is lacking before an efficient irrigation pumping plant can be installed.

It should also be emphasised that the maximum yield of a well is obtained only when the drawdown is at its maximum, i.e., when the water level while pumping is close to or at the bottom of the water-bearing formation penetrated by the well. Many wells used for domestic supply are pumped at rates far below their maximum capacities. Their yields could be increased by installing larger-capacity pumps and extending the suction pipes to near the bottom of the wells. Deep-well pumps should be installed as close as is practicable to the bottom of the well for maximum yield.

OTHER CONSIDERATIONS

This paper would be incomplete without some reference to a number of other points of importance, though discussion must be very brief.

(1) Water-table Fluctuations

The position of the water table is subject to great fluctuations due to variations in rainfall and other natural factors affecting recharge and discharge of the underground reservoirs. Wells sunk to apparently adequate depths in wet or normal seasons may fail in dry seasons owing to the natural fall in water level. It is always wise to sink a well deeper than may be thought necessary at the time.

(2) Quality of Ground Water

The quality of underground water in most parts of New Zealand is entirely satisfactory for irrigation of all types of crops.

(3) Depletion of Ground Water

At the present time in only a few small areas of the country is there any evidence for the depletion of underground water supplies through excessive use. If ground-water irrigation expands greatly, however, judging from experience overseas and from our admittedly inadequate knowledge of the ground-water resources of New Zealand, it may eventually be desirable to institute some form of control over the use of ground water in certain areas.

WATER DIVINING

The practice of divining sites for wells has been (and will continue to be) the subject of considerable argument. The official attitude of the New Zealand Geological Survey (and the personal opinion of the writer) coincides with the following official statement of the United States Geological Survey: "It is doubtful whether so much investigation and discussion have been bestowed on any other subject with such absolute lack of positive results. It is difficult to see how for practical purposes the entire matter could be more thoroughly discredited, and it should be obvious to everyone that further tests by the United States Geological Survey of this so-called 'witching' for water, oil, or other minerals would be a misuse of public funds..."
New Zealand

GEOLOGICAL MAP
MAIN GROUND

Scale:

0 25 50
0 50 MILES.

Great Barrier Id.

Auckland

Waikato Basin

Hauraki Basin
Bay of Plenty

New Plymouth

Manawatu

Wellington

Wairarapa Valley

Old hard rocks
(greywacke, schist, granite)

Meagre supplies
in joints only.

Younger rocks (consolidated)
(limestone, sandstone, siltstone)

Supplies variable,
but rather poor.

Fig. 4A - North Island
Note.—Because of the small scale the map is highly generalised. Many small areas of coarse alluvium favourable for large supplies of ground water occur in river valleys but have not been shown.
To all enquirers the United States Geological Survey therefore gives the advice not to expend any money for the services of any 'water witch' or for the use or purchase of any machine or instrument devised for locating underground water or other minerals." (U.S. Geological Survey Water-Supply Paper 416, 1917.)

Water does not generally occur underground in streams, but exists as a slowly-moving sheet saturating all permeable rocks below the water table. Nor is its source generally at any great distance—except in the case of artesian and other deep, confined aquifers, when it may be some miles away. The origin of 99 per cent of all underground water is in rainfall, generally at no great distance from the well itself. The statements of water deviners about narrow underground streams meandering through paddocks and supplied by water welling up from deep fissures in the bowels of the earth are so much bunkum. The only underground streams that exist are found rarely in areas of limestone and volcanic rocks, but not in alluvium. If you are reasonably sure that the underground strata are favourable for the occurrence of ground water, sink your well in the most convenient situation—where power is available, at a central spot commanding the paddocks to be irrigated, near your milking shed if for use in the dairy, near the house if for domestic supply—not across the road, or at the back of the farm, or on top of a rise, or in the middle of a gateway, or under a hedge (divined wells have been seen in all these unnecessary situations by the writer)—unless there are good geological reasons for such a site.

Diviners have failed to make correct predictions at least as often as geologists. When tested scientifically they have been found to be no more successful than laymen without pretensions to supernatural gifts, and rarely agree even among themselves. It could, however, be argued that they perform a useful service in persuading farmers (and others) to sink wells, by reason of their forthright and definite promises, where the cautious statements of an experienced geologist might deter a prospective well-owner. It can, however, be confidently asserted that wells sunk at random, with a modicum of common sense, stand just as much chance of success as those sunk on the advice of diviners.

GROUND-WATER AREAS

No attempt has been made in this paper to describe in detail ground-water conditions in the various parts of New Zealand where irrigation might be practised. (Figure 4.) Our present knowledge is hardly adequate for this task. Wherever alluvial deposits containing gravel or sand are to be found below the level of the water table, however, there is a good chance that wells yielding adequate amounts of water for irrigation can be sunk. In the North Island the main areas appear to be: the Heretaunga Plains around Napier and Hastings, the Waikato and Hauraki lowlands, parts of the Wairarapa valley, the Manawatu district, the Bay of Plenty, and possibly Poverty Bay. In the South Island, the Waimea Plains near Nelson, the Wairau Plains near Blenheim, the Kaikoura Plain, the Canterbury Plains and inland basins (including the Hamner, Culverden and Waiau districts, and possibly also the Lake Heron and Mackenzie basins) the Westland Plains, parts of the intermontane depressions of Central Otago, and the Southland Plains (including the Waiau River valley and the Waimea and Five Rivers Plains), all contain potentially useful aquifers. Besides these districts there are numerous smaller areas (too small to show on the map) in both islands in the major (and some minor) river valleys—especially those draining areas of hard rocks—that are underlain by apparently suitable alluvial or glacial gravels. It is inevitable that if wells are sunk in these areas, some failures will
result, but our present knowledge of their geology and hydrology is sufficient to justify the opinion that success is just as likely. As mentioned previously, if the yield from one well is insufficient more wells can be sunk.

As far as Canterbury is concerned some additional information may be worth recording. Areas that appear to be eminently suitable for ground-water irrigation—having highly permeable beds saturated with water rising to a level within reach of surface pumps, or pumps sunk only a few feet below ground level—include the following districts: Waikuku, Woodend, Rangiora, Southbrook, Ohoka, Kaiapoi, Clarkeville, Belfast, Harewood, Sockburn, Halswell, Ladbrooks, Lincoln, Springfield, Greenpark, Irwell, Leeston, Brookside, Dunsandel, Hororata, Tinwald, Flemington, Long beach, Hirds, Lowcliffe, Coldstream, Orton, Clendeboye, Milford, Orari, Temuka, Seadown, Waimate, Glenavy. Over much of the remaining area of the Canterbury Plains, the water level is such that deep-well pumps would be necessary, and the costs involved would be correspondingly higher; but there is good reason to believe that provided sufficiently deep wells are sunk, adequate yields could be obtained. Up to 300 gallons a minute have been obtained from a six-inch well between Ashburton and Chertsey, where the water table is about 100 feet below the surface, by means of an air-lift pump. Deep-well turbine and submersible-motor pumps could also be used. Wells in these areas, especially, should be properly developed and fitted with some type of screen so that for a given yield the drawdown is kept to a minimum.

CONCLUSION

There is no doubt that there is great scope for the increased use of ground water for irrigation in many parts of New Zealand. Canterbury, with its thick alluvial deposits, is better provided for than most other districts. Although there is always a certain amount of risk involved in sinking a well, especially if a high yield is desired, in many parts the chance of failure is small. More information can be obtained only by sinking more wells, and properly preserving all records of pumping tests, logs of wells, and measurements of well water levels. The Geological Survey offices will be pleased to receive any such records.

Ground water is in many respects preferable to surface sources for moderate irrigation supplies. Its greater reliability in dry seasons (when irrigation is most required) makes the expenditure on a first-class well only a modest insurance premium against crop failure and stock production losses, and emphasises the truth of the old Indian proverb “A well is nearer to man than the clouds.”

DISCUSSION

Mr Hunt: Will your Department advise farmers regarding the prospect of getting water from wells?

Mr Collins: Our Department is able to help farmers within the limits of finance, time, and staff being available. We are doing our best. We hope eventually to get sufficient money to cope with the requests for help. At present we are trying to develop an overall picture of certain large areas rather than trying to immediately accede to requests for information and advice from individual farmers. We will do what we can. If you are interested apply to the nearest office of the Geological Survey.
IRRIGATION: METHODS OF APPLICATION

A. W. Riddolls, Lincoln College.

A farmer who is considering going in for irrigation has to decide what method to use in applying the water. This is often a difficult decision, involving compromise between many conflicting factors. There are three main classes of methods which he may consider. One of them, sub-surface or underground irrigation, requires such special conditions that it is rarely used, so the prospective irrigator usually has to choose between one of the many systems of surface irrigation on the one hand, or one of the many systems of sprinkler irrigation on the other.

In surface irrigation the water is applied by running it over the surface of the land to be irrigated; it is sometimes called flood irrigation or gravity irrigation. In sprinkler irrigation the water is applied by projecting it through the air in droplets on to the land to be irrigated; this is often called spray irrigation or, sometimes, overhead irrigation, though I think the term "sprinkler irrigation" is more descriptive and less confusing. But whatever you call it, it is still just plain water when it comes down again in spite of fanciful claims one sometimes hears to the contrary. The effective advertising and publicity campaign for sprinkler irrigation conducted in recent years by manufacturing and sales’ organisations, has probably resulted in some over-emphasis of the merits of sprinkler irrigation compared with surface irrigation. Fortunately—or perhaps unfortunately, depending on the point of view—you do not have to be persuaded to buy anything to do surface irrigation, which as a result gets little publicity; but the sprinkler irrigation firms deserve full credit for their enterprise in developing efficient, light-weight, readily portable equipment that has made irrigation practicable in conditions where it would otherwise have been impossible or uneconomical, and for their promotion of research in sprinkler irrigation.

Although comparisons are said to be odious, there is so much misunderstanding on the relative merits of sprinkler irrigation and surface irrigation that it is important to try to compare their merits on the basis of labour requirements, capital costs and other relevant factors.

COMPARISON OF SURFACE AND SPRINKLER IRRIGATION

Labour Requirements

The relative labour requirements of sprinkler and surface irrigation methods are often argued. I have often heard it said that sprinkler irrigation requires much more labour than surface irrigation. There are so many different methods of surface irrigation and of sprinkler irrigation that such a sweeping generalisation is not justified. If we take labour requirements to mean man-hours of attendance on the job, which is the only way you can measure it, then some types of surface irrigation require far more labour than any kind of sprinkler irrigation. For example, contour ditch irrigation on steep hillsides with small streams of water may require as much as six man-hours per acre for each irrigation. On the other hand, in the border-dyke system in the Mid-Canterbury schemes, using large streams of water, seven or eight cusecs, about two-thirds of a man-
hour per acre is needed at each irrigation. Compared with this, we find that with our sprinkler system at this College we can irrigate with about three-quarters of a man-hour per acre, not much more than the Mid-Canterbury border-dyke schemes, although we irrigate with less than one cusec. In sprinkler irrigation the problem is not so much the amount of labour required as being tied to shifting the pipes several times a day, day in and day out. But a well designed sprinkler system is arranged so that pipes can be shifted at times which involve a minimum of interference with ordinary farm work. New developments in wheel or skid moves promise to reduce actual time for moving pipes to a minimum, if you are prepared to pay for the convenience. In surface irrigation, if automatic methods can be developed they will also greatly reduce labour requirements. To summarise on the labour question, sprinkler irrigation may require more or less labour than surface irrigation, depending on the types of system you are comparing.

**Economy in Water Use and Control over Application**

In economy in the use of the available water and in accuracy of control of the depth of application, well designed, carefully operated sprinkler systems are superior to surface irrigation systems. Economy is measured by irrigation efficiency, which is the percentage of water applied to the land that becomes stored in the root zone, where it is readily available to the crops. The border-dyke system is the most efficient of the surface methods, yet even with this system it is difficult to avoid uneven watering and large losses of water by deep percolation and runoff from the end of the strip; and while efficiencies of 70 per cent or more are possible, it is often less than 50 per cent, i.e., if half the water applied is wasted. Water wasted in deep percolation can raise the water table and cause drainage difficulties. For other surface methods such as border ditch and wild flooding, efficiency is usually lower still. On the other hand, with sprinkler systems properly designed and operated, although losses by wind drift and evaporation can be quite high in hot dry windy weather, irrigation efficiencies of the order of 75 per cent or better are usual. In the United States they have found that in areas where sprinkler irrigation has replaced surface irrigation, savings in water of 30 per cent or more are usual.

One other advantage of sprinkler irrigation is the ease with which the depth of water applied can be controlled to suit the crop and climate. This is very difficult to do with surface irrigation.

**Land Utilisation**

In surface irrigation much land is wasted in ditches, and dykes, often more than 5 per cent of the land area, and levelling operations may damage the soil structure and expose infertile subsoil. Ditches have to be cleaned, and ditches and dykes cause a serious hindrance to operation of machinery. These losses and inconveniences are avoided with sprinkler irrigation.

**Capital Investment**

The question of the capital investment needed for irrigation is an important one. Simple surface irrigation schemes such as wild flooding can be installed with an almost negligible capital investment. Even the most expensive surface method, border-dyke irrigation, costs no more than about £6 or £7 per acre to instal, unless the water has to be pumped, when the capital investment may rise to as much as £20 per acre. The installation for sprinkler irrigation almost always costs much more than this. It rarely costs less than £30 per acre, while £40 to £50 per acre is not uncommon, particularly if a long main pipe line is needed.
Water Costs

In addition to meeting capital charges on his investment, the irrigator will usually have to pay in some way for the water he uses. For surface irrigation, if a farmer is lucky enough to be able to take water by gravity from a nearby stream, his water costs may be almost negligible. If he is lucky enough to be situated in a public scheme such as the Mid-Canterbury scheme, where the cost of water is heavily subsidised by the Government, he is equally fortunate. Where he has to pump the water from a stream or well, pumping may cost him one shilling or more per acre inch, depending on how high he has to lift the water. But if he is going in for sprinkler irrigation, to pump the water at the pressure required to operate the sprinklers will usually cost about three or four shillings per acre inch for low to medium pressure systems, and more for high pressure systems, or where the water has to be lifted uphill. The water costs for sprinkler irrigation will almost always be greater than for surface irrigation. The greater irrigation efficiency of sprinkler systems is unlikely to make up the difference.

Crop, Soil and Land Surface

One advantage of sprinkler irrigation is that it can be used on almost any crop, soil type or land surface. On the other hand, surface irrigation is usually unsuitable on very flat land, or very irregular surfaces, for irrigation of seedling crops, or for pre-emergence irrigation of fine seedbeds. In such conditions, sprinkler irrigation may be the only possible method.

Size of the Irrigation Stream

The amount of water available has an important bearing on the choice of method of irrigation. While surface irrigation can be done with very small streams of water, it is tedious work and may be impossible on highly permeable soils where the water soaks in very quickly. But the sprinkler irrigation can be done easily with very small streams of water, so sprinkler irrigation is probably the better choice for limited water supplies of the order of half a cusec or less, or for even larger supplies if the soil is very permeable.

To summarise on the question of whether to choose surface or sprinkler methods of application, it is not so much a matter of one method being generally better than the other; it is more a matter of carefully weighing the advantages of either method on the particular area to be irrigated, and then selecting the method estimated to give the most economical irrigation. Generally speaking, for irrigation of large areas with ample water supplies and a reasonably uniform surface of the ground, surface irrigation would be chosen. For smaller areas with restricted water supplies, or with irregular surfaces, sprinkler irrigation would be chosen. In the latter case, careful consideration would need to be given to economic factors, because of the heavy initial capital investment and relatively-high operating costs of sprinkler irrigation. Because of these high costs very careful management will be needed to make sprinkler irrigation pay, in spite of its higher efficiency in water and land utilisation. On these grounds sprinkler irrigation is usually more suitable for high-producing farming systems such as for town-milk supply, or for horticulture, or for irrigation of small areas of special crops such as potatoes, mangolds, and seed crops. Unless the costs of the equipment can be reduced, it will be very difficult to make it pay in the long run on more extensive farming systems such as fat-lamb production.

SURFACE IRRIGATION SYSTEMS

Even when a decision has been made in favour of either surface irrigation or sprinkler irrigation, the farmer still has to decide which of the many different systems of surface irrigation or of sprinkler...
irrigation are best suited to his particular system of farming. I am not going to attempt to describe and discuss all the different methods of surface irrigation as this matter has been dealt with at previous meetings of this Conference and elsewhere. I should like to point out, though, that surface irrigation need not be confined to areas served by large public schemes, but can be done successfully anywhere there is a suitable source of water, by border-dyke and other methods. Farmers can easily do their own land preparation, using ordinary farm tractors and machinery. The main requirement is that the system should be well planned and operated to use the water as efficiently as possible, and particularly that lengths and width of border-dyke strips should be planned to suit the size of stream used, which should be measured accurately.

Although there are often adequate supplies of water available underground, it is usually difficult to extract it in large enough quantities for large-scale surface irrigation. One of our greatest needs for irrigation in this country is the introduction of methods used in America for boring wells several feet in diameter quickly and cheaply.

**SPRINKLER IRRIGATION SYSTEMS**

There are probably just as many different systems of sprinkler or spray irrigation as there are of surface irrigation. The most popular system in this and other countries for farm irrigation is the portable, quick-coupling sprinkler or spray line, fitted at regular intervals with slow-rotating sprinklers supplied with water under pressure by a centrifugal pump. The sprinklers may work at pressures ranging from 20 to over 100 lb per square inch, and their deliveries range from a few gallons per minute for low pressure sprinklers up to several hundreds of gallons per minute in the giant, high-pressure, rotary irrigators that can cover an area of up to two and a half acres from one position. Higher pressures permit bigger areas to be watered from one setting of the equipment, which results in a shorter length of pipe line and less labour in shifting the pipes. But this is achieved at the expense of a more costly pump and engine to give the high pressure required, higher pumping costs, uneven watering in windy weather, and greater evaporation and wind losses. So in general very high sprinkler pressures are undesirable except for special circumstances such as tall growing crops, and the low to medium pressure systems requiring shifts of 60 feet, or even 80 feet, at the most, are to be preferred.

Designing sprinkler irrigation systems is a job for specialists with expert knowledge. The designer must take into account all the relevant factors of climate, soil, crop, water supply, economic and management factors. The modern tendency to sell a range of standard sizes of irrigation systems is undesirable. I would like to see farmers consult independent irrigation specialists rather than rely solely on the supply firms to design their irrigation systems. Some of the firms have very good designers, but others, unfortunately, have not and there is the inevitable temptation for the firm to design according to what they want to sell rather than what the farmer really needs. The independent expert employed, say, by the Department of Agriculture, which already provides such an irrigation advisory service, could design the system for a farmer and supply him with a complete plan and specification. The farmer could then get quotations from more than one firm until he got what he needed at the best price. Of course the expert might advise the farmer to go in for surface irrigation instead if he found it would be more economical.

The rate of application of the water in sprinkler irrigation should not be so high as to cause appreciable runoff. The distribution pattern of the sprinkler is important; some give much more even
application than others. Distribution is greatly helped by smoothing or levelling the surface of fields before sowing down into pasture. This is only good husbandry in any case, but it is a practice in which Canterbury farmers are particularly lax. The most convenient and efficient power unit to drive the pump is an electric motor. If electric power is not available at reasonable cost, then choose a diesel engine. Petrol engines are uneconomical except for very small schemes. All engines that run unattended should be fitted with protective devices to stop the engine if the water supply to the pump fails, or if the engine overheats or loses its oil pressure. It is not usually satisfactory to use the farm tractor for sprinkler irrigation as irrigation must go on almost continuously in fine weather, when the tractor will probably be needed for haymaking and other jobs.

SPRINKLER IRRIGATION FOR TOWN MILK SUPPLY AT LINCOLN COLLEGE

Successful irrigation demands a careful study of economic and management factors. It is easy for advocates of sprinkler irrigation to point to occasional phenomenal results in very dry seasons like the past summer, when some fortunate farmers have paid for their irrigation equipment by selling hay at fantastic prices to their less enterprising neighbours. This doesn’t happen often, and it is much wiser to rely on conservative estimates of costs and production over a long period. For this reason we have begun keeping records of costs and production under sprinkler irrigation on the Lincoln College town-milk-supply dairy farm; records that we hope will eventually give a useful guide to the economics of sprinkler irrigation for town milk supply.

We use a portable sprinkler or spray line 880 feet long, with 23 slow rotating sprinklers spaced 40 feet apart, working at about 30 lb per square inch. This can be coupled into our portable main line 1060 feet long. Because of the odd shape of our paddocks we cannot always use all 23 sprinklers. We drive our centrifugal pump with a four-cylinder diesel engine and we can do over 400 gallons a minute if necessary. When irrigating pasture we usually make four runs a day of about three hours each, moving the sprinkler line 60 feet between settings. Each setting waters about one acre on average so we do about four acres a day, applying about two and a quarter inches at each irrigation. Assuming an average irrigation efficiency of about 75 per cent, this means that the effective application is probably between one and a half and one and three-quarter inches. We aim to irrigate at intervals of between 10 and 14 days, but the schedule can be varied to suit the crop and weather. In the past dry summer the irrigation system was invaluable. We were able to give light waterings to our vining peas and fodder crops at a critical stage in November and December. A paddock of eight acres of lucerne yielded an extra two cuts of hay, totalling about one and one-third tons, a valuable yield this season. Irrigated pastures gave good feed throughout when adjacent unirrigated pastures were badly burnt up. We conducted a trial of costs and results from irrigation in a 10-acre paddock of six-year-old pasture. We left one half dry and irrigated the other half 11 times with a total depth of about 24½ inches of water. Our records show that it cost us for diesel fuel and lubricating oil and making a reasonable average allowance for maintaining the equipment, nearly £3/10/- per acre to apply this water, or 2/10¼ per acre inch, exclusive of labour. The initial investment in the equipment, based on retail cost, is £39 per acre. We worked out the capital charges on this for interest and depreciation at appropriate rates and found it came to just over £3/10/- per acre per annum, or 2/11 per acre inch of water applied. On a commercial farm this
may be reduced by reduction from income tax. This makes a total of operating and fixed costs of just under £7 per acre for the irrigation season, or 5/9 per acre inch of water applied. The labour for shifting the pipes, refuelling and attending to the pumping unit averaged less than three hours a day or under three-quarters of a man-hour per acre for each irrigation, i.e., about eight man-hours per acre for the season. Most town-milk-supply dairy farmers manage to arrange their irrigation schedules so that this extra work can be done without extra paid labour, but if this labour is to be charged against irrigation, then eight man-hours at say 6/6 per hour makes £2/12/- per acre for the season, or 2/6 per acre inch of water applied.

In return for this we found that during the irrigation season from November to March inclusive we increased our dry matter production on the trial area of five acres by about 3000 lb per acre, from about 2400 lb per acre to about 5400 lb per acre. The record of grazing shows an average daily increase in grazing equivalent to three-quarters of a cow-grazing day per acre over the irrigation season. What this extra feed is worth depends on what use the farmer makes of it. On town milk supply three-quarters of a cow-grazing day per day should be worth 3/- a day in extra profit, or about £22/10/- per acre over the irrigation season, which would be a handsome return on the costs. But this is not the complete story, as obviously in a season of higher rainfall the extra growth due to irrigation would be less, while the capital charges would go on just the same. So the full story must wait until we have completed a cycle of wet and dry years, but it looks quite promising. The main benefit of irrigation in town milk supply would appear to lie in the removal of the fear of the effect of a dry season on production, with the possible loss of the quota. Irrigation should also have a long-term beneficial effect on pasture production.
IRRIGATION : FARMERS' EXPERIENCES

(a)

I. A. Gerrard, Winton.

Irrigation in Southland

It was considered somewhat of a joke by some people when I ventured into irrigation. What made me consider applying water to the soil was grim necessity. We had experienced one dry season and were in the midst of a drier one in '54 and '55. I had been reading of irrigation in Australia in the Australian Agricultural Journal and wondering what the possibilities would be like on my farm. I was visited by Hector McIntosh, Dairy Board Consulting Officer in November, when I asked him what he thought about the idea, and his reply was that I could not go wrong.

I have a farm in what is known as Central Southland, 20 miles inland, due north of Invercargill, two miles west of Winton. I'm in the very fortunate position on my farm in that I have no tile drainage worries. The Oreti River flows through the west part of the farm and the subsoil being running gravel, the surplus of water, if any, has no trouble in draining away. I also have a spring fed creek running diagonally through the east part of my farm. So much for the situation and the type of subsoil.

Our average rainfall for the past six years is 33.9 inches. That makes an average rainfall per month of 2.8 inches. However, as you are well aware, he who turns the tap on above sometimes, some months, neglects to give us our monthly quota. We get spells of nor'-west winds, but our main wind is from the sou'-west. This wind seems to dry the soil more than any other weather condition.

Now gentlemen, I'm no irrigation expert—far from it. I am just an ordinary farmer the same as you, but will now endeavour to give you my experiences acquired from irrigation.

As I see it, there are three main essentials to study if you are contemplating going in for irrigation. First and foremost is a good supply of water or an economical method of obtaining the same. By that I mean that it does not entail too much finance for drilling, etc. Secondly, you need a reasonably warm air temperature, and thirdly a pasture or crop that is worth while irrigating. If you have the first two essentials it should be no difficulty to find a crop or pasture which under irrigation will give you considerably added return.

Last season my farm consisted of 130 acres, 30 acres of it being outside flood stop-banks and not ploughable. On that area I carried 60 head of cattle and 300 ewes. In the late spring I purchased a further 70 acres adjoining my farm, but due to the lateness of my purchasing this property I was unable to stock it fully. The pastures were all run out bar one, and consequently my carrying capacity for this year is not very big. Because there is no water at present available on this block for irrigation purposes I've already booked a dragline to be ready for next season. Under irrigation and renewed pastures I'm looking forward to this block of land having the same carrying capacity as the home farm.

My dairy herd of usually 35 to 40 cows is given priority in the matter of pastures. As you are aware, the dairy cow will not produce unless she is contented and she is not contented till her stomach is
kept filled to capacity all the time. Without irrigation I would not have been able to accomplish this, these past two summers. To further convince you of this statement I will tell you that last season, reputed to be the driest for 40 years, my herd of 38 cows averaged 400 lb of butterfat in 237 days. The average butterfat per cow at the Awarua Dairy Factory which I supply is 250 lb. Production at our dairy factory for January, February, March, 1956, dropped 49 per cent from December; my production decline over the same period was 20 per cent. I attribute this entirely to irrigation.

When do I decide a pasture is in need of moisture?

I've adopted the principle of irrigating before the soil becomes really dry. By doing that you obtain a much more rapid pasture growth response. As yet I've not procured any of the soil moisture measuring instruments. The handy old pocket knife will give you a fairly good indication as to how moist the soil is. Using the pocket knife cut a cube of soil and knead it in your hands. If the soil does not mould together into a nice moist ball, then it's time to use the irrigation plant.

How much water should I apply at a time?

This of course depends on how dry the soil is. If the soil is only partially damp, an application of three to four hours with my spray unit I find sufficient. Should the soil be really dry I find up to nine or ten hours is required. You can see by the above statements it does not pay to permit the soil to become too dry before you begin to irrigate. From experience I've found that frequent applications of short duration give me better results than large applications over a longer period.

I've found, though, that this does not apply in the case of lucerne. I irrigated 40-odd acres of pasture and my experience was that for quick response the timothy (S48) and Montgomery red clover pasture outshone all other pasture mixtures. Next came cocksfoot, then H1 and then perennial rye, white clover mixture. I use the electric fence for the herd and during the real hot dry days I found that my three-acre block of three-year-old timothy stood real hard grazing better than any other pastures. As the herd was grazing, my irrigation unit was spraying in the paddock at the same time.

On real luscious pastures, bloat is one of our biggest enemies—in real hot days and especially the evenings I've seen my wife and myself afraid to leave the herd for more than half an hour. So far, since I've been irrigating I've had no bloat on my irrigated pastures. I'm told that this is an accepted fact, provided the pasture has been watered no longer than ten days before it is grazed. I've grazed pastures, Montgomery ones too, at various stages of growth up to 10 inches in length and had no bloat worries.

Last season I irrigated till the first week in April. We had experienced quite a few early frosts by that time and I was surprised at the response the pasture gave. At the end of April I closed up three irrigated paddocks, a total of 15 acres, and barring a good harrowing they received no special treatment. We had the hardest frosts last winter that Southland has had; some of them over 20 degrees. These pastures seemed to grow slowly all winter and by the first of September they had an average length of six to eight inches. My herd begins calving from 25 August onwards and this spring I did what I have not been able to do in the past, that is put the cows on grass as soon as they calve. I consider this one of the greatest advantages of irrigation. Not only did they go straight on to grass but I also was able to keep the grass up to them. Other seasons I have applied sulphate of ammonia to the pastures in July—even tried applying it in April; but if conditions have been just not
right I have been at times without grass till the end of September. I'm not a scientist and cannot give the correct reason for it, but I've particularly noticed the tremendous number of worm casts on irrigated pastures. I believe worms have a big part to play in pasture growth.

Every spring, usually round about Labour Day, I ridge about six acres of soft turnips for autumn feed for the herd while there is a lack of pasture growth. I normally feed these about the second or third week in January. However, since I've been irrigating I've found they aren't necessary till the end of March. As these turnips are pulled and carted out with tractor and trailer each day, I've found irrigated grass a big saving in time and labour.

Talking of soft turnips—I did a bit of experimenting with them and irrigation this spring. I germinated a section of them and when they went into rough leaf I gave them an inch of rain. They were the best turnips in the paddock when it came to feeding them.

My potatoes were a sorry-looking lot with the dry conditions, so I decided a little irrigation might be worth while. I gave them three applications, each of which I considered equal to three inches of rain at 10 to 12 day intervals. It was really remarkable how those King Edwards grew.

Last year I could save no pasture hay; I was so short of feed, and had to buy my requirements. This year I've saved 1000 bales of hay and will also tell you about a paddock which last year did not have a hoof on it from end of October till the following March. There was just nothing on it to eat. So this year I ploughed it and sowed it out in lucerne which I germinated with my irrigation unit. I gave it applications of water whenever I could spare the unit from my pastures and today I've got quite a respectable stand of lucerne. I've had no previous experience of lucerne, but according to those who have, I should not require to save any pasture hay next year.

Should you decide to do topdressing at any time you can get quicker results by using the irrigation plant to wash your fertiliser into the soil immediately after applying. I did this on several of my pastures and it means a lot, especially in a dry season.

When I was invited to give this paper I was a little apprehensive, because I'm irrigating in a small way and realise that irrigation in Southland is only in its infancy. I've seen what a benefit it has been to me and also realise the immense possibilities irrigation holds for the future. I can assure you, gentlemen, that once you undertake irrigation, no matter how small a plant or method, you will be impressed with results to such an extent you will increase the size of your unit.

For example, I've doubled up on my original unit. My first plant was one which I assembled myself on a four-wheeled iron trolley. The pump, lines, sprays and engine for an 11-chain pipe-line cost me £604. The local blacksmith made a trailer, painted and all, for £29. The pump was driven with a 9 to 11 h.p. Coventry-Victor diesel engine and delivered approximately an inch of rain over an area of a bit over an acre in three hours. I've been so impressed with results that at the end of this season I purchased a 16 h.p. Lister unit ready to kick off next spring. With spray irrigation manual labour comes into the picture, but I found no great problem using the simple A.B.C. coupling to shift the 11-chain line in 15 minutes on my own.

Those people who purchase irrigation with the idea of an insurance policy for a dry season have the wrong idea to my way of thinking. Even in a normal season irrigation will further increase your production.

To conclude, gentlemen—lime and the drag-line made Southland, but after considerable reflection, my firm belief is that Southland farmers will either have to carry less stock or go in for irrigation.
The farm is on the Tarras-Cromwell road 18 miles north of Cromwell. The land is of glacial formation and typical mica schist not being deficient in phosphate or lime. The farm is comprised of small ridges and hollows. Each paddock has light gravelly ridges with free subsoil and heavy black soil in hollows with clay subsoil. Forty acres are worthless, being stony bumps above water level and unploughable. The irrigation water is brought by gravity race from Lindis River, a distance of 11 miles. Our allocation is one head per 100 acres. The cost is 16/3 per acre delivered at top of farm.

I took over management of this place in 1939. At this stage the farm was run in conjunction with a high country sheep run. The annual draft of ewes and wethers was brought to farm in early autumn. An endeavour was made to fatten wethers before the works closed. The healthiest managed to get to works—but 90 per cent were rejected with lympho. The ewes were put to the Romney ram. Thirty per cent of these died during winter and early spring. The remainder gave a 40 per cent lambing, i.e., somewhat less than 40 per cent of ewes put to the Romney ram. The wether lambs were fattened, killing out at 30 lb. The ewe lambs were wintered and sold as two-tooths. It should be pointed out that no regrassing was carried out at this stage. Gradually the Merino sheep were sold rather than being brought to farm.

I decided my policy would be to run one thousand three-quarter-bred ewes, putting half to Down rams and half to Romney rams, thus breeding own replacements. Although paying 16/3 an acre on 400 acres I found that water allocation of four heads was only sufficient to irrigate 300 acres. The balance of 100 acres is utilised in the following manner: 30 acres ploughed out of lea with 20 acres of it in rye-corn for greenfeed and ten acres of it in swedes for seed. Thirty acres are sown down in permanent pasture of following mixture: 1 bushel perennial ryegrass, 3 lb white clover, 2 lb Montgomery clover. This pasture is kept for ryegrass seed in first season. Twenty acres of wheat (X7) is sown after the swede crop and green feed saved for seed. Twenty acres of lucerne for grazing is not irrigated. In favourable seasons 30 acres of the 300 acres is shut up for Montgomery or white clover seed. We now have 120 per cent lambing average; 900 lambs are fattened averaging 36 lb; 300 Romney ewe lambs are kept as replacements; 250 annual draft ewes are sold; and the death rate is five per cent.

Irrigation Experiences

(a) A successful scheme must be paid for at per acre not per head.
(b) System of irrigation is dependent on the fall and contour of country. Perhaps more land could be border-dyked in Central Otago.
(c) In Central Otago with rainfall from 12 to 17 inches the water required varies from three-quarters of a head to one and a half heads per 100 acres depending on contour, soil texture and winds.
(d) Life of irrigated pasture: after five years pasture is not so vigorous, but may be very useful for ten years.
(e) Ordinary grass mixtures are satisfactory under irrigation, but H1 does not stand close grazing in December-January.
Three-quarterbred ewes thrive on irrigation but on light land halfbreds are suitable.

It is not necessary to have footrot on irrigation if rams purchased each year are isolated for six weeks before tupping. It is not necessary to trim the feet of a flock which is free of footrot.

Californian thistle and Scotch thistle thrive for two reasons: (1) water carries seed from hill country, (2) pastures are grazed too hard during dry months leaving sward too open.

Lambs fatten readily if pastures are irrigated and shut up three weeks to a month before weaning. The Montgomery clover in the pasture is very useful for lamb fattening. Lambs will not thrive if the pasture is too succulent. It has to be hardened off for at least a fortnight for weaned lambs. When lambs are still with the mothers it is necessary to harden pasture for a week after irrigating. For the last three seasons we have fattened weaned lambs without access to water, and the weights have increased by two pounds.

Most schemes in Central Otago run short of water in December, January and February, which are critical months. The carrying capacity is necessarily regulated to suit these dry months. We think that if full water rations were available carrying capacities could be increased by 50 per cent. While an irrigation farm is not easy farming, water is the life blood of Central Otago and there are thousands of acres in the province crying out for water.

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S. J. Lister, Temuka.

The paper I have prepared on spray or overhead irrigation is based on my own experiences over the past six years; what I have learned about the subject would fill a small book and what I have yet to learn would I am sure fill a very large volume. Spray irrigation is in its infancy in this country, and indeed to some degree in nearly every country in the world. However, great strides have been made over the past few years and much development is still taking place. I am sure that just as the agricultural tractor superseded the draught horse, and the header harvester replaced the old threshing mill, so will spray irrigation help to remove that old "bogey," "Drought." And who of us have not had that forcibly brought home to us this past season?

I farm just over 200 acres of heavy silt loam in the Temuka district and 900-odd acres of light land similar in many respects to Ashley Dene, in the Orton district, running a flock of 2,200 ewes. Half of these are mated with the Romney ram to supply our own replacements and the other half to the Southdown. All lambs are fattened on the farm and no difficulty is experienced in fattening the Romney wethers. Certified ryegrass, white and red clover, and lucerne are harvested. Very heavy and constant crops of wheat had been taken off the property over a long period of years.

I will endeavour to discuss in everyday terms my basic organisation, because here I must state that I do not think that anywhere else in agricultural engineering, can matters become so complex through horsepower requirements, fuel consumption, water volume, pipe diameters, frictional loss, and pressure loss, and nothing could prove so costly to operate as a badly designed and operated irrigation plant.
My plant, for that matter, all plants, consists basically of a suction hose, internal combustion engine, centrifugal pump, and light alloy pipes taking the water to the point of distribution. We use 1,000 feet of four-inch pipe. I have used to date two giant rainers covering from one to two acres per setting. These operate on high pressure and require more horsepower to operate but require much less manpower to shift. As the patterns are affected by strong winds, this system has a lot to commend it in areas where winds are not too prevalent or strong. As I live in an area where stiff easterlies blow fairly consistently, medium pressure multiple spray lines are I think, more satisfactory under these conditions, requiring of course more constant shifting, but taking less horsepower to operate.

My plant has an output of 20,000 G.P.H. or nearly one cusec—this is also close on one inch per acre per hour. We have complete coverage of the whole farm at Milford which is watered by a natural spring creek. This gives an output of 30,000 G.P.H. where it enters my property, and because of a series of springs 80,000 G.P.H. as it leaves my farm. I have a coverage of the whole farm through the creek running diagonally through the centre; I have a low-lift, high-volume pumping unit that will lift the creek out into irrigation ditches that reticulate to the farthest points of the farm. This unit lifts 36,000 G.P.H. using only a 6 h.p. diesel and enables me to reach any portion of the farm with 1,000 feet of main feed pipe from the main 40 h.p. spray unit. We do not, however, attempt to irrigate the whole farm as it would take a plant of greater output capacity working long hours to give adequate coverage over 200 acres. We did, however, cover 100 acres from October until February this year, getting good results in October and November with an application of one and a half to two inches per acre on good covered pasture as well as boosting white clover and ryegrass crops kept for seed.

However in late December and January with the high rate of evaporation, applications of not less than three or four inches were necessary to maintain growth. Indeed at this stage I am sure if too much was attempted and not thoroughly watered the whole system could break down through the evaporation rate being greater than the application rate. The response from lucerne was most encouraging and good cuts were obtained at approximately 28 day intervals. Experience has shown that application should be made several days before cutting as the heavy foliage prevented a large degree evaporation experienced if you apply water after the cut has been removed on the bare stubble. Surplus growth on irrigated pasture paddocks was topped with a forage harvester leaving a fairly long stubble. This material was carted to the light land, some fed out to stock and the balance made into silage, incidentally coming out now as very good silage.

A ryegrass paddock kept for seed and also one kept for white clover were very dry after harvesting, but an application of four inches in each case with spelling for three weeks produced a very good re-growth and made fine fat-lamb feed. In fairness I must say that a good rain experienced a fortnight after spraying was a big help. However portions of the paddock missed during spraying as well as unirrigated portions of the farm soon dried out and the effect of the rain was lost, whilst the sprayed areas have kept their cover. Indeed, I have noticed over the years that areas sprayed during a previous dry autumn have kept their cover all winter and been much quicker away in the spring.

I would submit my conclusions on my own experiences as follows: Have your plant well planned, preferably a direct-coupled diesel. Every horsepower the maker designed it for is then put to work direct on to the pump shaft. Too many counter shafts and drives use up
valuable horsepower. This is often unavoidable in order to multiply the engine revolutions up to the required pump speeds. Because on no other farm work is so constant a load going to be put on an engine, plants worked by tractors are all right so long as there is a spare tractor for this purpose. If the farm tractor is used there are usually several weeks of work before the machine is available for pumping. Too little and too late can be very costly. Never let the ground dry out or the pasture stop growing. Good pasture control should be exercised to fully utilise the extra growth. Plan well the paddocks to be sprayed—only the best pastures are worth the cost. (Trying to revitalise old run-out pasture is like telling a hair-raising story to a bald-headed man.) Lucerne will give the greatest return. Spraying will give the nearest approach to natural rain and does not appear to encourage the ingress of smothering grasses. Good pastures require about two inches per acre at least, fortnightly intervals to maintain vigorous growth. Special crops like swedes, white clover, and potatoes, are well worth the cost of an application of two inches at the correct time.

On a recent trip to Australia where I saw hundreds of spray plants working, potatoes were not grown in some areas unless provision for spray irrigation could be made. Yields rose from an average of five tons per acre to 16 tons per acre. An application of one to two inches per acre on paddocks cut for silage or hay ensures a quick recovery. I base the application of one to two inches on the assumption that no rain has fallen, but that is more or less on the farmer's own judgment.

As a sheep farmer with a large portion of my farm light land that is liable to dry out very quickly, I find spray irrigation good insurance that I will have silage and hay for winter feeding and at least a portion of my farm growing grass under almost tropical conditions. Living as I do in a predominantly dairying district, many plants have been put into operation these last two years. The results this year have been most pronounced, having experienced one of the driest years, and milk production down generally. Those under spray irrigation have maintained their average. One dairy farmer with a herd of over 50 cows actually was up considerably during the driest periods of December and January, whilst another milking over 40 cows on town supply maintained his usual production. But for intensely irrigating 50 acres he would have been forced to use winter silage and hay, or dry off most of his herd. Market gardeners have also cause to be thankful for their foresight in having plants. There are, however, no short cuts. It requires consistent but not hard work. Evening and early morning applications are most beneficial, as conditions are usually more calm and there is not the same evaporation rate. All-night sessions are all right so long as you do not require sleep, and to keep peace with your neighbours excellent mufflers on engines should be fitted. Spray plants are expensive items of machinery and almost any year on any farm or market garden there are periods where an application of one inch of rain on special crops or pastures is of great benefit. Early application is most necessary to catch crops and pastures before the wilting stage is reached.

Costs

This is perhaps the portion a lot of you have been waiting for, but like the shrewd politician I will try not to get myself into a trap I cannot get out of. Most plants require to be tailor-made for the individual farm and could vary in price from round about £400 to £2,400. Some figures published could be almost frightening. So of course could figures of the value of a farm, and the price eventually paid. I would say in round figures about £10 or £12 per acre of a capital expenditure would set most farms up with an efficient plant. Pipes of too small a diameter and great distances to be pumped
should be avoided at all costs. Initial outlay is the greatest cost. There is enough competition among the importers (who are doing a very good job), to leave very little between them regarding costs. Although long hours are worked maintenance is very light. If pipes are handled with care they should be almost everlasting.

Operating costs are just the cost of what fuel and oil are used. Diesel units will operate over long periods at a much lower cost than petrol units. Although when once in position these different units will work for several hours without attention, I find it is almost a constant job for one man to be in attendance. That being so, I think that consideration should be given to a plant with the greatest possible output per hour. Faster methods of shifting spray lines are being evolved. I am sure spray irrigation is here to stay, and will become a means of taking one of the greatest uncertainties out of our farming activities in areas where only a limited quantity of water is available, whether from springs, creeks, or underground sources. Much is yet to be learned with the co-operation of the importer, the farmer, and the research worker.

To those in areas where a limited supply of surface or underground water is available and where the nature of the soil does not favour heavy floodings, there are definite advantages to be obtained with spraying. We are, I believe, on the verge of the greatest means of increased production since the advent of topdressing our pastures began.

Throughout this paper I have not drawn comparisons between spray and flood irrigation as it is acknowledged without question that flood irrigation is a much cheaper method of applying water. However, when the time comes when much greater demands are made on the water available, overhead spray systems are a means of utilising effectively a much smaller volume of water. They will, I think, also be less serious in their leaching effect on the soil, while the cost of levelling and border-dyking could go a long way towards the initial cost of an overhead spray system. Some complications are sure to emerge when the draw-off from creeks deprives landholders further down of their normal supply. The underground water bill will take care of the situation when pumping from bores lowers the water table too far. However these situations are yet a long way off.

The first plant I purchased six years ago delivered 12,000 G.P.H. through three-inch pipes using a 32 h.p. kerosene burning engine. My present plant gives 20,000 G.P.H. through four-inch pipes using a 38 h.p. diesel, while a plant about to be delivered to me now, has an output of 30,000 G.P.H. through five-inch pipes using 28 h.p. I point this out only to stress the importance of going the limit in pipe diameters. Through this, operating costs can be lowered considerably. Smaller diameters are in comparison economical if a longer period is taken, and not too great a volume of water delivered. I originally went into spray irrigation as insurance against periodical drought. The time will come, I am sure, when the availability of water for irrigation purposes will have an influence on the potential value of any farm.

(d)

J. E. Fairhall, Blenheim.

Although the title of this paper embraces a very wide subject, I will try as briefly as possible to give you some of my experiences and impressions during my two seasons of spray irrigation.

My farm consists of 227 acres of flat land, but with some depressions six to eight feet deep following old creek beds. Half the farm
is silt loam on sand. The remainder consists of half sandy loam 10 to 14 inches on gravel, and half sandy loam on stony gravel with gravel ridges appearing on the surface. The soil, apart from one or two small areas, is extremely free draining, and therefore subject to serious shortages of soil moisture in our normal summers. Average rainfall is about 27 inches, but badly distributed with serious shortages between November and April.

This unit is basically a mixed farm, with at present a fifty-fifty balance between sheep, 800 fat lamb breeding ewes, cropping and small seeds. Seventy to 80 acres of crop are grown annually—mainly peas, with smaller amounts in wheat, barley and ryecorn. Small seeds include ryegrass, lucerne, and red and white clovers; the acreage of these varies from year to year, depending on the season, but usually accounts for another 40 acres closed. About 20 acres of lucerne are closed for hay. This leaves approximately 80 to 90 acres of available grazing for 800 ewes and their lambs from August until mid-January.

I might add here, prior to irrigation and also sub-division of the farm, I was able to carry only 300 breeding ewes and crop 60 to 70 acres, but only in exceptionally favourable years was I able to get any small seeds.

Irrigation commenced on the farm two seasons ago when we were experiencing a severe drought, and crops were suffering badly, with prospects of obtaining winter hay-supplies practically nil.

Not having any streams on the place, or any other external means of obtaining water, but knowing that plentiful supplies for house and stock existed 10 to 12 feet underground, which never gave any trouble in dry periods, we decided to dig a well.

A local contractor with a "Quickway" clam bucket was engaged. The scheme went very well after we had encouraged the bucket through the top six feet of rock hard soil, until we struck water, and then were faced with the problem of stopping the slosh of the water from crumbling and undermining the sides of the hole. It was decided to take the risk, and continue without boxing. A centrifugal pump with a capacity of 200 gallons a minute was used to test the well, and when the hole had been deepened sufficiently to give what we considered would be sufficient water, a four foot by three foot concrete pipe was lowered into the hole.

This well was used quite successfully until about six weeks later when a subsidence of clay blocked off the flow, and we were forced to deepen the hole with the clam bucket again. This time an eight-foot long pipe was used to bring the mouth of the pipe up out of the danger zone from falling clay. All went well until we were in the act of lowering the eight-foot pipe when the pin holding the wire rope through the pipe came undone, and allowed the pipe to drop on its side in the hole. The results were disastrous; instead of a neat five-foot diameter hole, we ended up with a crater 16 feet across with our pipe lying on its side in the bottom. Sufficient to say, is that we eventually righted the pipe and obtained enough water to continue irrigating. On later attempts during the first season we always had a boxing handy to dig inside and stop the sides crumbling when the bucket struck water. In one well we were fortunate enough to get a plentiful supply at eight feet deep, but one was abandoned after we had reached 16 feet with still insufficient flow. A lot was learnt about soil profile and likely and unlikely places to dig for water during the first season. Some farmers tried digging large holes with the "Quickway" dragline, but apart from the large amount of ground taken up by the hole, trouble was experienced with the sides falling in, and so blocking the flow. I mention all this simply because it caused a lot of frustrations at the time, and gives you a little of the teething troubles we went through in obtaining water.
Today, digging these wells is not looked upon with so much scepticism, but there is still a certain element of doubt and risk as to whether the well will be successful. The job usually takes about four hours. The procedure is to dig inside three foot six inch diameter reinforced concrete pipes eight feet long which usually slip down as digging proceeds. A large amount of the credit for this improved method goes to the ingenuity of the contractor who has purchased an Impact Clam Bucket. This has a 600-pound hammer on the top of it which is used to drive the open bucket through the sub-soil, no matter how hard it is. This bucket has been used successfully to dig holes down to 60 feet in depth.

To date I have six wells on the farm, from which 130 acres of ground can be irrigated if required. The average depth is 10 feet and will give us 130 gallons per minute, and still hold with about two to three feet of water in the pipe. The average cost, including the pipes and hire of “Quickway” is £45 per well. A point may be added here, that a well being pumped 16 chains from another makes no difference to the water level in the one not being pumped. The water we seek when digging comes straight up from underneath into these wells.

By reference to the plan on the blackboard, you will see that with another four wells, I will be able, if I so wish, to irrigate any paddock on the farm.

The next problem was the plant. I purposely kept the size of this small; firstly, capital required had its effect, but secondly, and the most important feature, I wished to experiment and find out how it worked in with the existing management and labour. I have found the potential is almost unlimited, but labour and management are the biggest limiting factors.

The basic plant cost £620 and comprised 25 feet of suction hose, a two inch two and a half inch high head centrifugal pump primed by a 20 gallon tank, and driven by a nine-horsepower radiator cooled diesel engine, all mounted on a portable frame on pneumatic tyres, 20 feet of outlet hose with 32 lengths of quick coupling, three-inch aluminium pipe and eight monsoon type sprinklers. About halfway through the season a further 12 four-inch aluminium pipes were added, which enabled coverage of 20 acres from a hole centrally situated between two 10-acre paddocks. The only change to the basic plant was the replacement of the radiator-cooled diesel, with an 11-horsepower air-cooled motor. This latter motor proved a much more reliable and trouble-free running motor for irrigation purposes. One could not arrive in time to save a motor if a radiator failed or a hose gave out.

After two months’ irrigation I began to think of increasing the size of the plant by putting in a central mainline with a “T” section at its end, feeding into the sprayline. From all angles this was a good policy, and far more efficient, enabling a 10-acre paddock to be covered in eight moves, as opposed to the existing 13. However, available labour squashed this plan, for by now we were in the middle of harvesting operations and I found it difficult to keep the small plant operating even with three men available. Far better, I thought, to keep this small plant going to capacity than have a larger unit, with more capital tied up, lying idle for periods. Investigation was also made into the possibilities of laying a permanent four-inch pipeline around the farm with hydrants for take-offs into each paddock. Two diesel pumping units were to supply the water for three spraylines. The total cost, by the time two additional houses had been built for two more permanent men, was in the vicinity of £20,000 or approximately £88 per acre. Although the complete farm manage-
ment programme would have had to be revolutionised, there is no
doubt that such a scheme would be the ultimate in obtaining maximum
production.

Briefly summarising production during the first season. I was
without hay for winter requirements and required a minimum of at
least 1,000 bales. Good hay for feeding in-lamb ewes was selling at
a minimum of 15/- per bale, which would have cost me £750 for my
requirements. With irrigation of 10 acres of lucerne and six acres
of rye-clover pasture I harvested just over 1,000 bales. Besides this,
I was able to plant a crop of peas on 31 December (something I could
never have done without irrigation), which netted about £200, and
irrigate sufficient late summer and early autumn feed, to complete
fattening 300 lambs and flush 760 breeding ewes at a time when the
district was experiencing a severe drought. I therefore consider quite
a sizeable amount was paid off the plant during the first season’s
operation.

This season a further four wells have been dug, and now 135 acres
can be irrigated. I say, can, but with the existing plant it is impos­
sible to do this efficiently and thoroughly.

To mention some of the interesting points which have been experi­
enced this year. In one paddock, a division was made when sowing
the crop of peas, and this paddock having been a winter green-feed
area was fairly late being sown down. During December, irrigation
was commenced on one half and just as this was being completed
we had one inch of rain. I immediately thought that it would not be
any use irrigating the other half as the ground seemed wet enough.
However, when the crop was harvested the irrigated patch went 38
bushels per acre, but the unirrigated patch only 23 bushels per
acre. There was absolutely no difference in the treatment of these two
crops—same variety of peas and the same type of ground.

In another paddock, I tried to obtain two crops of peas during
the same season. The first was sown on 21 September and the crop
cut just before Christmas, but due to overcast and showery weather
harvesting did not take place until 16 January. The second crop was
sown on 27 January, but due to striking a very cold March with light
frosts, and this at a time when the peas were in full flower, the yield
has been very low. Despite this, I consider that provided the first
crop can be sown in early September and that the second crop is sown
the first week in January, it would be possible with an average spell
of weather to get two crops. Naturally I am assuming a paddock in
a high state of fertility is selecte d. A quick-maturing variety such
as Massey is of course essential and if the crop is taken for canning
this would considerably reduce the risk. I feel there is a need for a
quick-maturing variety of peas, suitable for growing under irrigation.

Lastly two stands of lucerne were sown in October on some of the
light ground on the farm. One stand was irrigated and produced a
good cut of hay, but the other area receiving no irrigation became very
weedy, recovery not occurring until the commencement of the autumn
rains.

Stock carried during the season included 760 ewes and their 800
lambs. From the end of August until the end of January there was
only 70 acres of available grazing for these sheep; 200 ewes were
sold fat in December, and all but 150 of the lambs had gone away fat
by mid-January. These lambs averaged 32 pounds. I do not con­
sider this would have been possible without the growth produced by
irrigation.

This year 26 acres of pasture received four one-inch applications,
20 acres received one after ryegrass harvest, 20 acres of peas received
two, and 10 acres of lucerne two. Perhaps we are trying to cover too
much ground with such a small plant, but the policy has been to concentrate on certain selected areas, and provided these receive sufficient, we try to keep the plant going full time on other areas of pasture. Although we are by no means obtaining 100 per cent production on all of them, we are able to keep fresh and growing paddocks available for the stock most of the time.

Obviously another plant, preferably one on skids for pasture watering, and additions to the present one are required, but under the present credit squeeze policy, a farmer receives no more sympathetic hearing for a loan on an irrigation plant than he would for a new car or a seaside cottage. Surely some consideration could be given along the lines of Marginal Lands grants, or, at least, make finance available through the normal channels, provided of course, a definite line of increased production is planned by the farmer. I understand a 40 per cent grant is made for such schemes in England.

Local dealers list resistance to buying anything new, water supply, finance and labour as the leading factors preventing farmers purchasing plants. From the farmers' side, I would say most of these factors are correct, but I must add, that many consider the present extremely high cost of aluminium pipe to be rather excessive.

Interviews made with eight local farmers, i.e., within a radius of 10 miles of Blenheim, all using low pressure systems, showed an average cost per plant of £1,000. These were capable of applying one acre-inch every three and a half hours at an average cost inclusive of labour, fuel and operating costs of 7/- per acre-inch. One of these farmers has tried out three methods of irrigation—flood, high pressure and low pressure, and claims he is getting far greater efficiency with much lower operating costs from the low-pressure system. All have been irrigating as much as possible, but without impairing efficiency on certain pre-selected areas of crop or pasture.

There are approximately 45 spray plants working in Marlborough and results from these show there is little doubt about their capabilities of increasing production.

Farmers could considerably increase their efficiency in the use of irrigation if transpiration and evaporation figures for various districts could be given over the air with weather broadcasts as Professor Walker has stated they are in England. It is pleasing to note that the College has commenced full-scale research on sprinkler irrigation and its potentials, and we look forward to the results from this experimental work to fill a much needed guide towards sprinkler irrigation in New Zealand. Such problems as water requirements for plants, transpiration and evaporation figures, soil fertility behaviour under irrigation, management and costs are but a few of the items which need investigation and research to enable us to attain maximum production under irrigation.

To summarise my own experiences, I have found it will eliminate the hazard of drought, but I must modify my farm management to take full advantage of my opportunities. More fertiliser is required to replenish soil fertility from increased yields taken. I also consider it may be advisable to increase sowing rates, for highest production can only be obtained when there are enough plants to utilise fully the space available for growth. The economies must be closely watched as with high capital costs in pipe and plant the whole thing can soon become unprofitable if a close check is not kept on costs and returns. Provided sound farming practice is adhered to, the potential for increased production under irrigation seems practically unlimited.
Mr Cummins, South Canterbury: Mr Lister made reference to a point of argument among farmers—flood irrigating. He mentioned leaching when flood irrigating is in progress. Is there any evidence of that and to what extent does it occur?

Professor Walker: If you waste water, in other words if water leaches through you are almost bound to lose something from the soil. But that is not the main source of loss. The major losses must be due to heavier crops and greater carrying capacity. This would have to be watched. You must use more fertilisers, and pay more attention to the drain on such trace elements as cobalt and copper which are so essential for stock. Lime would be the one exception: you could lose appreciable quantities of lime by leaching if over irrigating.

Question: Has Mr Gerrard irrigated any clay subsoil country as opposed to shingle subsoil country and then had rain? Could you get into trouble on the clay subsoil?

Mr Gerrard: I have no clay subsoil. I have three to four inches of average soil, then river gravel. I cannot give any information regarding clay subsoils. I would think you would have to be careful what you put on. If you overdid the watering naturally it would not be able to get away.

Mr Lister: During January you could put on one inch of rain on a clay subsoil. The trouble is to get enough on quickly enough. If you have rain on top of two inches of irrigation the land might get over-watered, but without rain there is no fear of over-watering.
FARMING OVERSEAS

(a)

H. E. Copland, Dromore.

I wish to thank the Conference Committee for asking me to present a paper at this Conference and I congratulate Lincoln College officials on holding the Conference here again this year.

The trip I was fortunate to make took me through part of Canada, across U.S.A. by plane to England and Scotland, then back across U.S.A. by car on our way home.

Farming conditions in those countries are very different from our own, mostly on account of the severity of the winters and in the U.S.A. the heat of the summers.

After travelling in those countries I realise more than ever how vitally important our primary produce is as far as our national economy is concerned. Those countries I saw have a tremendous mineral wealth which New Zealand has not got. Being a farmer producing meat and beef I was more interested in that side of farming and marketing and I feel quite certain that if our red meats were as well handled and displayed for sale in the United Kingdom as they are in the United States of America, there would be a lot more consumed. The American people eat beef in a big way, which is easy to understand after seeing how efficiently and attractively it is put before the public. We are spending a lot of money on advertising in England which is a good thing, but I can assure you folk that our lambs do not look or feel very attractive in some of those butchers' shops at Home. England has a damp climate and you folk know what frozen meat is like when it is thawed out in damp weather. Anyone knows that frozen meat cooked fresh from thaw is a vastly different proposition from that cooked stale from thaw. Until we market a pack which will enable the English housewife to thaw in her home and cook fresh, we will always have her at a disadvantage with our product.

I am sorry to say that I was really disappointed with the hygiene and facilities for handling the meat on Smithfield market when one realises that 1000 tons of meat has to be man-handled into and out of that market every day. I realise that the handling of meat in England is not altogether our affair, but I want you to realise that our meat values are based on what meat realises in the Smithfield market. For the benefit of those who have never been to England, I want to tell you that a proportion of the stall-holders in Smithfield have not got any refrigeration and our frozen meat, which has been displayed for three or four hours in the morning, does not look very attractive. Therefore it has to be sold at a discount and I am sure that does not help the producers here. Consequently I say that we as meat producers, should be concerned and should be prepared to do something about it. My biggest disappointment was that our representatives had told us that the facilities were up to date. I can tell you I do not agree. I have a few pictures to show anyone who doubts what I have said.

After seeing the way the pre-packed meat is put before the American housewife and how easy it is for anyone shopping in the Super-markets, I am sure that in those cities with huge populations that the butchers' shops as we know them will go out of existence.
As a matter of fact, butchers' shops as we know them are already "out" in U.S.A.

I know a producer who is willing to get 200 carcases of lamb pre-packed at his own expense and take whatever they realise in England. It would only take a few more of us to join him, then we will get somewhere. After all the original industry was developed by the courage of our forbears to comply with conditions that existed in their time. Surely if modern conditions demand improved methods which take courage, let us use some of it instead of allowing our product to be marketed as it was last century.

**Farming and Animal Husbandry in the United Kingdom**

From a farming point of view I think England would be fairly difficult. The trees are really beautiful but I think they would tend to make farming more difficult, especially on the good land where there are more trees and the growth is more prolific. Shelter within reason I think is a good thing, but I feel sure that the prevailing winds in New Zealand play a big part in keeping our stock healthy.

They farm in England on entirely different lines to our New Zealand farming. The holdings are smaller and the winter conditions are very vigorous. My impressions were that those who criticise English farming are unfair. I do know that if the average New Zealand farmer was asked to farm over there, he would very soon want to return to New Zealand.

I congratulate the Grassland Division of the D.S.I.R. on the good work that has been done in New Zealand, but after being overseas I have come to the conclusion that our Government has not given our Livestock Division enough assistance in animal research work. I am sure the farmers in the United Kingdom, given our climate, would be a long way ahead of us in animal husbandry. I think the stockmen in the United Kingdom a long way ahead of us in that branch of farming; otherwise under their housing and hand-feeding system they would not keep their stock as healthy as they do.

It has always been a mystery to me how the United Kingdom farmers can market heavy-weight lambs at such a good price, but after seeing the type of breeding ewes they have, I have come to the conclusion that we are sacrificing cutting quality for carcase and wool. My reasons for making this statement are:

We in New Zealand are developing a well-woolled, low-set, blocky type of breeding ewe and I am sure that as that type is more developed we will have to kill our lambs lighter and lighter to get good cutting quality. When one sees that our South Island first grade light-weight lambs are making more per pound in London than the North Island selected light-weight Downs, we must realise that it is cutting quality consumers want. If the average New Zealand fat-lamb farmer looked back through his meat and wool returns (1951 excepted) he would find that his fat-lamb returns would be more than double his ewe-wool returns. I am sure that if we could increase our lambing percentages and carcase weights without sacrificing cutting quality, it would help our national economy. United Kingdom lambing percentages of 150 to 170 per cent are quite common. Last season, farmers were getting £8 for 50 lb lambs—about 3/8 lb.

Irrigation

California has a population backing of millions and has developed citrus fruits, lettuce and other fresh green vegetable production to comply with this huge ready market. Summer conditions are dry and hot day and night, hence there is prolific growth. Canterbury rainfall 28 inches reasonably spread, average temperature much lower particularly during darkness. Summer rains are practically unheard

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of in California. Their loose grain is elevated in huge heaps at railheads. Huge costly irrigation schemes in this extraordinary climate are economic but would certainly not be so but for what is termed as the truck garden industry. Therefore a comparison with Canterbury conditions is not practicable.

CONCLUSION

1. I would urge the Meat Producers' Board to study more attractive ways of putting our meat before the consumers, concentrating on what would satisfy the housewife both from a hygienic and economic angle.

2. There should be more assistance to the Livestock Division for Animal Husbandry Research. In fact I would like to see more co-ordination between the Livestock and Agricultural Divisions in pasture production and animal diseases.

3. We should increase the research work put into fat-lamb breeding. If we could increase our lambing percentages and carcase weight without losing cutting quality it would be a big help to our national economy.

(b)

Melville Turton, Ashburton Forks.

Overseas I consider that the grasslands people work better with the animal health people than is done in New Zealand. We seemed to lose the necessary co-operation when the Departments split up and the Department of Scientific and Industrial Research came into being. I also think that in New Zealand farmers keep too much to themselves as far as stock health is concerned; particularly is this the case with facial eczema and ill thrift of hoggets. It is disappointing to know that there is no diagnostic station in the South Island, yet they have two in the North Island. You farmers should press for one and see that a station comes down here. Overseas I noticed that as far as tuberculosis and contagious abortion were concerned there was very little trouble. In America it was compulsory to have stud herds tested. If they did not have clean herds nobody would buy their stock. This is the only way to clean up the tuberculosis problem—the tough way.

One thing which appealed was pellet feeding, particularly with lucerne pellets. We saw machines in America with lucerne going in at one end and farmers carting away the pellets from the other. Often, concentrates were added during the process. We saw stud sheep at 6,700 feet, being fed wholly on dry feed; tight-wooled Corriedales. I have never seen better in my life, and they were all fed dry. I also saw up to 32,000 cattle in one lot being fed dry. The majority of their cattle are fattened in these feeding lots. We have a lot to learn about this type of feeding. Pellets would be very handy in such times as the present when so many turnip crops are affected by the virus disease.

One of the biggest shocks I received was the tremendous surplus of food. England at one time produced 40 per cent of her meat; today she produces 63 per cent. America has tremendous surpluses of wheat, meat, wool and pineapple. She is talking of taking land out of crop production; some must go to producing meat. Meat consumption in the United States is 161 lb against Great Britain's 126 lb per annum.
I consider the standard of living of the New Zealand farmer higher than that of any others I saw. We have few other natural resources than the ability to produce grass and we must rely on primary produce for the maintenance of our standard of living. Should we attempt to produce more? I say keep on producing more. If lamb is worth two pounds now and then drops to one pound, then we must produce two lambs for every one we are producing now. The only way to do it is with the help of the scientist. We should appreciate our scientists more and see that they are not attracted away.

DISCUSSION

Mr Quigley, Waipara: When overseas you must have seen a lot of nitrogenous fertiliser used. How do the results achieved from these nitrogenous fertilisers compare with our system of replacing most of the nitrogen by the clover?

Mr Turton: They have very cheap nitrogenous manures there. They apply them very freely, but I don't think they get better results than we do. They do manure much more heavily over there than we do. They will put manures on with the crop, and then manure again by spraying the foliage.

Mr Fechney, Aylesbury: You mentioned the cattle feed lots in the States, but did not mention sheep feed lots. Could cattle feed and sheep feed lots be of significance in this country?

Mr Turton: Cattle go in to the lots for three months. The weight gained runs from 2 lb to 2.79 lb per day when the concentrates are applied. This compares with 1 to 1½ lb in New Zealand. The sheep in feeding lots look disappointing and slab-sided, but on killing you would not have such a loss of offal as with sheep here. They are quite healthy.

Mr Earl, Waikari: Is anything being done with regard to an agreement with regard to quantities of meat arriving on market at any one time?

Mr Turton: Perhaps Mr Lowe of Mid-Canterbury Meat Board could answer this; it is really outside my province.

Mr Lowe: The Government in Britain has pledged itself to reduce the cost of living and will not lightly interfere with the supply of meat coming into British market if it will help to bring price down.

Mr Grigg, Blenheim: Regarding 50 lb British lambs; are all British lambs heavy and if so why are they preferred when highest price New Zealand lamb is lighter?

Mr Copland: The usual practice in England and Scotland is to kill lambs heavier than that. They are often what we would call hoggets. They mostly use the Border Leicester-Cheviot cross. The North Cheviot sheep are popular with the Scottish farmer because of the great lambing percentage and rapid gain in weight of meat.
Dr Burns paid a tribute to the chairman and summarised the papers and the discussion.

Mr Hunt: I take this opportunity on your behalf to thank Dr Burns and the staff of this University College for the great things they have given us. We all agree that the members of the staff in the papers they have given us here have really extended quite a bit beyond the normal expected of them. They have given all they had to give. We should now give them a really great vote of thanks for their good work.

Mr Bowmar: I have to thank Dr Burns and the members of his staff who have very kindly come over to our quarters in the evening and discussed various problems and their opinions with us. We have only one complaint: I think there has been too much talk and too little sleep. I wish to extend to them the sincere thanks of those who have been in residence for their assistance and the value of the discussions in the evening.

Mr Hunt: I want to thank “the backroom boys.” I also take the opportunity of congratulating the Young Farmers’ Clubs for sending such a large representation to this Conference. Young farmers have to increase production in the future and this is the place to get the background. I wish also to make special reference to the papers read by farmers at this Conference. They did an excellent job. Lastly, I thank our friends of the press; we have to publish ideas and the press has always been very helpful. Our radio friends have disappeared, but I will pass on to them our thanks for their co-operation.

NEXT CONFERENCE

The next Conference will be held at Lincoln College on 22, 23, 24 May, 1957.