ROTHAMSTED RESEARCH

Modern Changes in the Treatment of Light Soils

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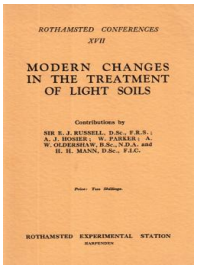

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ROTHAMSTED CONFERENCES

XVII

MODERN CHANGES IN THE TREATMENT OF LIGHT SOILS

Contributions by

SIR E. J. RUSSELL, D.Sc., F.R.S.; A. J. HOSIER; W. PARKER; A. W. OLDERSHAW, B.Sc., N.D.A. and H. H. MANN, D.Sc., F.I.C.

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ROTHAMSTED EXPERIMENTAL STATION

HARPENDEN

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MODERN CHANGES IN THE TREATMENT OF LIGHT SOILS

BEING THE REPORT OF A CONFERENCE HELD AT ROTHAMSTED ON MARCH 20TH, 1934, UNDER THE CHAIRMANSHIP OF

Sir E. J. RUSSELL D.Sc., F.R.S.
(Director of Rothamsted Experimental Station)

With Contributions by

SIR E. J. RUSSELL, D.Sc., F.R.S.; A. J. HOSIER: W. PARKER; A. W. OLDERSHAW, B.Sc., N.D.A. and H. H. MANN, D.Sc., F.I.C.

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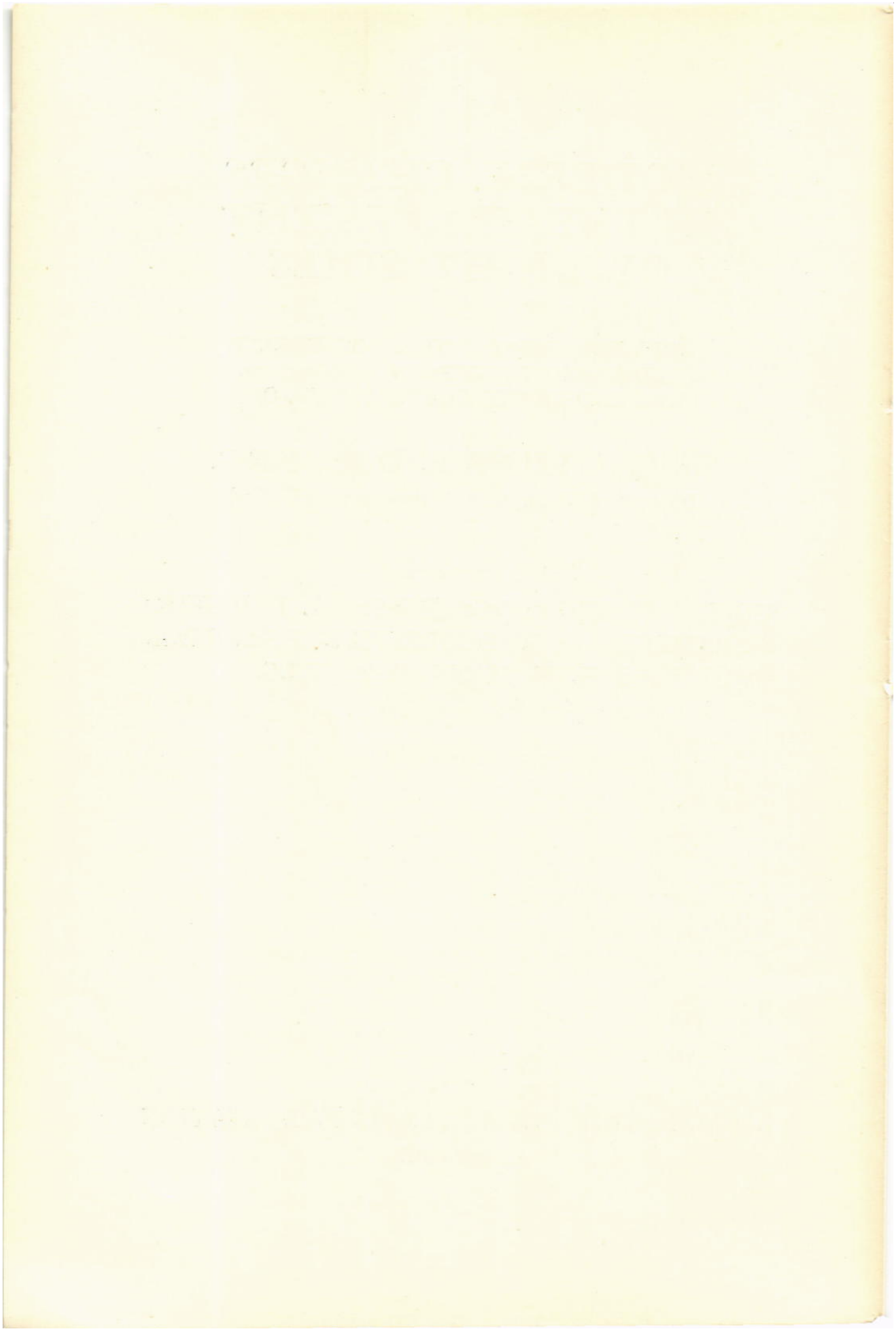

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FOREWORD

By Sir E. J. Russell, D.Sc., F.R.S.

The light soils of England have always presented difficulties to cultivators. In the old days very little could be done with them; they were left as wastes and heaths, and were in general disrepute. The coming of the four course rotation, however, and the development of sheep farming, opened up considerable possibility of improvement and they were enclosed and brought into cultivation. Sheep help wonderfully in farming these light soils; the "Golden hoof," to quote the old farmers, cannot yet be fully replaced by any artificial contrivance and so long as arable sheep-farming paid, and so long as satisfactory prices could be obtained for the barley that followed the sheep, so long could these soils be cultivated. There were of course always difficulties due to failure of the root crop through drought, fly, and other troubles. These difficulties were reduced in some places by growing a series of fodder crops for sheep, so that if one failed another would still be available. Some most ingenious sequences of cropping were devised, especially for the light chalky soils of the Southern Counties, and the technical management was admirable.

With the general rise in costs of farm production, the fall in prices of sheep, and the preference for lamb over mutton, the old arable sheep farming has ceased to be profitable and is fast going out. Summer feeding on grass is now the usual method and the light soils do not lend themselves to this. They do not easily carry grass, and if they are kept as arable they must be well farmed, for, if anything in agriculture is certain, it is that light soils badly farmed soon become hopeless. Light land is a paradise for weeds and also it easily becomes sour.

There are, in fact no short cuts to light land farming; it must either be done decently well or it will drive the farmer out of business. The trouble is to find some system that combines hope of profit with efficient cultivation.

This was the purpose of the present and the two preceding Conferences at Rothamsted. Several possibilities were discussed.

Market Gardening is specially adapted to light soil, because it necessitates intensive culture. For many years it has in certain regions been successfully adopted. Bedford has long been famous for its vegetables: so have Kent and Worcester. Parts of Suffolk round Woodbridge and elsewhere were equally well known in the old days when London had to be supplied by coasting vessels. In recent years market gardening has considerably extended; two of

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its crops, Brussels sprouts and potatoes, have been taken up by farmers so enthusiastically that the market gardener can no longer regard them as peculiarly his own affair.

If the demand for vegetables become much greater the light lands would be well able to supply them, and farmers would have a promising source of revenue. This revenue was fully discussed at an earlier Conference.† In many ways it is attractive but it is limited: the markets will not absorb more than a certain amount of vegetables and anything in excess is liable to be wasted. The canning factories are giving a new element of stability to the growers by the extension of the contract system, but they will take only the highest quality produce and the lower grade material is very apt to remain unwanted.

Two farm crops are very suitable for the light soils, and around them several systems of cropping could be built up. Sugar beet and potatoes both grow well on these soils. Like the market garden crops they respond to high cultivation and indeed are much more likely to prove profitable if well done than if treated shabbily. Both repay deep ploughing, which is specially useful wherever there is a pan. Potato growing formed the subject of the last Rothamsted Conference. It is also dealt with here in Mr. Oldershaw's paper in which he shows how, on the Suffolk Heath, potatoes were successfully grown on derelict land regarded only as waste. The trouble had been the sourness or acidity to which light soils are especially liable; when this was remedied by a dressing of 5 tons of lump chalk per acre, crops of 12 tons or more potatoes per acre were obtained simply by the use of artificial manures: the benefit of the chalk was specially marked in dry seasons. The result is interesting because the potato is more tolerant of acidity than most agricultural crops, indeed overliming is apt to favour scab. It is evident however, that a light soil may be too acid even for the potato crop.

Sugar beet also does very well on light soils. It is much less tolerant of acidity than potatoes, but on the other hand it stands drought better. In Mr. Oldershaw's experiment the chalked land gave an average of 12½ tons washed beet per acre over the seven years 1927 to 1933, while on the unchalked land the crop almost always failed. Such striking responses to lime or chalk are unusual, but many sugar beet growers lose yield by neglecting to apply lime; this is, perhaps, one of the commonest mistakes in growing this crop.

Using sugar beet and potatoes as pivots in the system, Mr. Oldershaw has devised rotations to suit the light soils of Suffolk. Grass is not included, but lucerne is, and this furnishes green food for horned stock, pigs and poultry.

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†Rothamsted Conf. Reports, No. 15. Recent Developments in Market Gardening, Rothamsted Experimental Station.

*Rothamsted Conf. Reports, No. 16. Problem in Potato Growing. Rothamsted Experimental Station.

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The use of lucerne on light soil is discussed by Mr. Parker who successfully farms several hundred acres of poor land in Norfolk. He also grows sugar beet and carrots, another root crop specially well suited to light soils, but he has neither turnips nor mangolds. His grain crop is barley, also well adapted to light land, and in order to avoid damage due to wet weather at harvest—one thing over which the farmer has no kind of control whatsoever—he uses a drying plant to dry the grain. This works well in Mr. Parker's hands but it is a risky proceeding for general adoption when the grain is intended for malting, and farmers are not advised to use it except after consultation with the maltster. If drying were likely to become general we would organise a conference at Rothamsted in the hope of finding some way of agreement on the matter.

One of the most striking improvements in light land farming, however, is that made by Mr. Hosier on his farm at Marlborough. He is on a light chalky soil, though favoured with a higher rainfall than either the Suffolk or the Norfolk farmers mentioned above. But unlike them he keeps mainly to grass. As is well known, he does not accept the old doctrine that sheep are the best animals for farming the light soils; he prefers cattle as being heavier, and therefore better treaders, and also as being less selective in their grazing. So he goes in for dairying and he keeps his cows out of doors on the poor, light chalky land, milking them in the open in the New Zealand fashion and using movable bales; in consequence the manure is deposited straight on to the land, so avoiding waste and cost of cartage and distribution. Poultry also are folded on the land. The treading of the cattle and manuring of the poultry and cattle improve the hill grass out of all recognition, breaking through the mat, which otherwise is a great obstacle to improvement. In wet seasons the effect is specially good, and while the lower lying grass would be badly poached the hill grass specially benefits. He can now keep 1 cow per acre on his own land. On the better parts of the farm he grows fodder mixtures of peas and oats or rye and tares cut green for silage or for hay: this supplies winter feeding. After a few years the grass has reached its maximum improvement: he then ploughs it up and grows three or four excellent cereal or other crops for sale, then he seeds down again. Even the new seeds, however, are grazed by cattle; the treading and grazing keep down "twitch"—one of the worst weeds on light lands—and they ensure a good development of clover.

Besides turnip beetles, wireworms often cause trouble on light land. They are perhaps the worst of the soil pests because there is no sure and easy way of dealing with them. Mr. Hosier tells us he has no trouble with wireworms which he attributes to the close grazing of his grass land and the careful picking by the poultry. We have long wanted at Rothamsted to investigate the control of wire-

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worms and this year we shall have the opportunity as we have an attack over a good deal of the arable land.

Mr. Hosier's method has the advantage of bringing the land periodically into grass and leaving the grass down for some-time. This is not usual on the market garden or sugar beet and potato systems. Dr. Mann deals with important difficulties that arise where light land is kept under arable cultivation with one crop only : a deterioration in yield in which soil exhaustion, accumulation of diseases and pests, and perhaps other factors come into play. It is specially well shown on the permanent wheat and barley crops on Stackyard Field, Woburn, and there are indications of some such deterioration on certain old market garden soils elsewhere. Putting the land down to a long ley is probably the surest way of dealing with the trouble, but experiments will shortly, we hope, be begun at Woburn to discover the causes and if possible to find other remedies.

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THE POSSIBILITIES OF DAIRY AND POULTRY FARMING ON LIGHT SOIL

By A. J. Hosier.

(*Marlborough, Wilts.*)

There is a vital difference between agriculture in this country and that of any other. We do not grow enough for our own needs and practically every other country has a big surplus of foodstuffs. That being so, it behoves us to look round and see what products we are most fitted to produce. As far as possible our aim should be to produce the most expensive articles in order to keep down the value of imports. This would involve the employment of more labour and a higher money value output. If we have to import foodstuffs, let it be those foods which we find it difficult or impossible to produce, or articles such as certain feeding stuffs which will help us to cheapen costs of production on our own specialised articles. A tariff on oats, for instance, looks good for the farmer, but tariffs on any of the feeding stuffs is bound to put up the cost of producing articles like beef, bacon, eggs, milk and its products. On farms where the chief output is meat, milk, and poultry, high prices of cereals and feeding stuffs raises production costs. On my own farms I have usually 700 or 800 acres of land under the plough, which, before I purchased it, had been used for corn and sheep. But that method of farming does not appeal to me because the output is too low. I have been using this land for growing cereals, and grinding these up for my stock, but two new factors have cropped up within the last year or two which have forced me to alter my methods

The first new factor was that, although the cereals were useful for my stock, the straw seemed to have completely lost its market. Consequently I have either to feed it to my stock, or let it remain in the stacks and rot. In other words the straw is now a liability instead of an asset. Whatever method of harvesting I adopt I cannot get away from the liability. If I use a combine harvester and leave the straw on the land, it is a great hindrance when ploughing and cultivating, and worse still on our light soils, when ploughed in, it keeps the land so puffy and light that it spoils the next crop unless well rolled and consolidated. On some of our acid soils it takes a long time to decay and this again introduces complication.

The best way I have found as yet, to use up the damaged or secondary straw, is to cart it out on to the newest and tenderest young pastures, spreading it where my milking bail is to travel. The milking cows tread the straw in out of the way, and, used in that way, it is a very useful dressing. The straw also is a protection against excessive poaching of the land.

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The second new factor which has forced me to change my methods is a tariff on cereals and feeding stuffs. We now find it necessary to sell all our cereals and buy foreign feeding stuffs. This, of course, involves heavy transport costs, both when selling the grain and when buying other food stuff, and moreover the holding is not such a self-supporting concern. Instead of growing a large acreage of wheat, oats and barley, harvesting the grain, and stacking unwanted straw, I am now growing such things as peas and oats, or rye and vetches, and cutting them green for silage or hay. Except for an occasional piece of wheat, oats or barley, my principle sales-crops are milk, meat and eggs. In this way I am using the haulm as good fodder, and, if cut at the right time, I get all the nutriment in this fodder without the cost of threshing and grinding.

For the past few years light hill arable- and down-land has been going out of cultivation because it has not been profitable to farm on the old system. Hundreds of thousands of acres of such land have, I suppose, become derelict. Folding sheep and growing grain became unprofitable, and the ordinary farmer could not conceive that the land was suitable for any other system. Such was the state of affairs when I purchased Wexcombe. Mechanised corn growing with artificials alone is not the remedy. One must have humus and organic matter ; and the problem is to get this in the land with the least expense, or better still, to put it there free of charge. I am very fond of using artificials, but I regard them as the *builders* and not as the *foundations* of our crops. I have found that this light hill land can be as profitable and productive as a good deal of so-called good vale land. Having farmed some of both for years I have been in a position to make comparisons, and my conclusions are that if I was looking round for a block of land, it would certainly have to be *dry* land and probably light hill land, because it could be bought cheaply and farmed cheaply. If there is to be any land permanently down to grass, let it be of the wet, heavy, or very hilly sort. Personally, any farmer who has to farm such land for a livelihood has my sympathy. I would rather be saddled with some of the light hill land that has gone derelict. Farmers have not yet realised the value of this type of soil for our changed system. Once having obtained a block of dry and light land, I should proceed to lay on water to *every* field on the farm. I should fence it with 3 strands of barb wire and iron standards in fairly large fields, say, from 20 to 40 acres. If it was a Wiltshire hill sheep and arable farm there would be a proportion of old downland, I should grass down most of the arable for a period if it was poor, using something like a Cockle park grass mixture. Having got this far, I should commence dairying on the open air system, and poultry keeping on the folding system. In the first stage of the venture I should have to provide summer grazing and hay for the winter feeding from the new pastures. The downland would be invaluable

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for carrying the stock in winter during the first two years and until there was a sward of turf to keep the cows up. During the early stage artificials would be applied to the young grasses, and the cows and the poultry would be kept there as much as possible. When the winter rains made the land tender the cows and the milking outfit would be moved on to the downs and fed with hay and concentrates until the early spring when they could again go back on the young pastures. I have reclaimed hundreds of acres of downland and made it into useful dairying land (some of it was previously covered with heather). The procedure was to " fold " the milking plant over the land a section at a time, the wetter the weather the more good was being done. There is nothing like " hoof culture " for that type of land and indeed nothing else seems so effective. I have seen a piece of my old down pasture well trodden out in winter time, some grass seeds sown and chain harrowed in, and the followingsummer it resembled a new pasture. Many an old pasture, especially on light land, becomes so matted, and the mat has become so deep that the roots are in suspension, and consequently no amount of moisture can be of use, and artificials in such cases are useless. Using a rejuvenator or cultivator is only playing with it, and improvement will be slow. It requires consolidation. A 20 ton roller would do good if it could be used often. One of the troubles with light upland pastures is that it becomes " puffy " and the roots seem to rise. The treading of sheep is certainly a help but they are not heavy enough, and gradually that accursed mat forms. My experience has been that cattle treading is far more effective than anything else, and curiously enough they do the *most* good on hill land when they would harm some vale pastures. When our cows are driven into the compound each day in wet weather they tread in the mat and squeeze up the mud so that the fibres decompose and the whole nature of the face is changed. That one operation systematically folded over a down will usually transform the surface. But that process must be followed up with heavy grazing to prevent its reverting to its former state. I have seen worthless old downs, after two years of this treatment, produce a hay crop of 50 cwts. per acre. I usually get a down pasture well consolidated and bare, and then apply suitable artificials. These, together with the cake-fed droppings and urine, give remarkable results. With plenty of moisture and plant food, some of the light " blow away " land makes really good dairy land ; it is warm, early and very responsive—the limiting factor is moisture. Some years ago our County Organiser took a turf from my improved down, and one from the other side of the wire fence, from unimproved down. Both were cut the same size and fitted into boxes, but the turf taken from the improved part was nearly double the weight of the other ; it was noticeable how the fibre had diminished.

What I have said about consolidation on old matted grassland

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is applicable to new pastures on light soils but to a lesser degree. The best and quickest way to make a pasture is to feed it with cattle (not sheep) for the first two or three years. I have often sown a piece of foul land to grass instead of summer fallow with good results. The plan has been as follows :—

Sow the seed without a " nurse " crop (the weeds and twitch are a " nursecrop ".) By the time the clovers have changed leaf, the weeds, etc., will cover the ground. I then turn a herd of cattle on to graze it, taking care to remove them in wet weather. The cows' feet consolidate the land and this encourages the young clovers and helps to strangle the " twitch ", and, by grazing off the rubbish and the blades of twitch, the clovers are further encouraged, whilst the same process has the opposite effect with twitch grass ; the grazing and treading encourages the " seeds " and kills out the twitch. Fields treated in this manner have been ploughed out in about three years and found to be perfectly clean, but remember, the fields in this case must be grazed continuously.

I am a great believer in what I call " dual purpose " farms, *i.e.*, land that can be used either as arable or as pasture—there are many advantages.

When old pasture land gets to its maximum fertility there is no extra response to the further manuring that accrues from the cake feeding of dairy cattle and folding the poultry.

1. With dual purpose land I can plough out and take a sale crop for 3 or 4 years, *i.e.*, cash the fertility.
2. In a dry summer on hill land new pastures can be depended upou for a better crop than older pastures.
3. Grass, cereals and most crops grow much safer and become less affected with pests when the crops are frequently changed.
4. Ploughing out the land sweetens it and therefore *all* farm stock are kept more free from disease.

I very seldom summer till land, because first I am losing a crop, and secondly I am spending money unnecessarily ; when it becomes foul or poor I lay it down and graze it for a period in the way I have described.

The system I have adopted is to break up each pasture after it has been down a few years and become fertilised with the residues from the cows and the poultry, grow 3 or 4 sale crops, and lay it down again to grass. As far as possible I intermix the grass fields with the arable so that I can, if necessary, make use of the early bite from new seeds, or lattermath ; or if some new seeds need treading I can have my milking bail on an adjacent grass field and turn the cows into the new fields for a few hours daily ; also in a dry summer I get a lot of milk when the older pastures are dried up. There is nothing like animal husbandry to keep up fertility on light soils. When I intend breaking up a grass field, I put my milking

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bail and the poultry folding pens over it as heavily as possible through the late autumn and early winter. It is then heavily manured without labour and incidently all the urine is distributed too, without waste. After this operation there is very little grass to plough in. It can readily be seen that such a procedure as I have described is an excellent preparation for a future crop. I have not yet grown beet, but if I do this plan will be adopted and with my portable equipment I can make good use of the leaves without having to cart them long distances. When it is not practicable to put the bail over the land immediately before ploughing out, I fold my poultry over and this is an excellent preparation, because in addition to fertilising, the hens scratch the surface, clean the land and pick up harmful pests such as grubs and wireworms.

It will interest you to know that since I have adopted this method, I have never had any trouble with wireworm—the fact that the grassland is always well grazed has, I think, something to do with this. I have demonstrated that, on much of our light soils, cows and poultry can replace sheep with advantages to the cows, the poultry, the land and the farmer. Some of my thin land (3 ins. off the chalk) after years of liberal treatment, will keep a cow per acre, winter and summer, given plenty of moisture. Some people think of sowing land down to grass as almost criminal folly and a waste of its potential possibilities, but that is by no means true. If treated in the way I have described the output from grassland will surpass the output per acre of arable land on average light soil In 1926-7 on one section of this grass land a milking herd gave a gross output of over £40 per acre—feeding stuffs of course were bought, but no poultry were kept at that time. My 7 milking herds are in 60/70 cow units and are managed by a man and boy. It is of vital necessity that all winter fodder should be handy for the use of each herd, otherwise extra labour would have to be introduced. My system, therefore, is to cut and stack the hay and silage where it is grown, and in winter time we aim to keep each herd fairly near a stack of hay. On each section of land used for a dairy of cows, one unit of poultry can be kept—a unit of poultry is 160 folding pens with 25 hens in each house. This unit also is managed by a man and boy. The houses are moved on to clean ground every day ; the area covered in a year is approximately 1 acre per house, or 160 acres for the unit. The addition of the unit of poultry just about doubles the cash output from each cow area without having to pay extra rent for the poultry farm. This system is like perpetual motion ; the cows keep the grass short for the hens, and the hens make the grass grow for the cows, and incidentally it has been found that poultry-manured grass is extremely rich in protein. During the drought last summer the poultry land kept green much longer than any other. I think the ordinary corn-growing farmer would obtain great benefit from a

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folding unit, by folding over his temporary leys before ploughing.

I have not yet taken up pig keeping, but when I do, it will be on a folding system as it would work in with my present system, and still increase output from the same holding.

I do not introduce grass sheep into my system because they are apt to damage my pastures by their selective grazing, they require a much more elaborate fence, and finally they are not heavy enough for the light land. Some of my friends tell me that I have too much wild white clover in my pastures ; they say I should get earlier and later grazing with certain other grasses, but I find that where I have lost my clover I have lost my crop—the other grasses grow more profusely if the clovers are present. Others have told me (in years gone by) that such heavy manuring would tend to eliminate the clovers, but that again is not true. On my best land the clovers grow and are grazed by the stock during each mild spell in winter. About the middle of last January I moved a herd of cows into a field that had been rested for 3 months and the production of milk increased from 104 to 118 galls.—all other foods were fed the same as before. I have often noticed that, even in winter, a change of pasture increases the milk.

The same thing applies to egg production ; the hens produce more eggs when being folded over good well grazed grass with plenty of clover in it.

The value of the dung being deposited by the stock directly on to the land is much higher than when carted from the ordinary farm-yard, because there is no loss and again there is the urine which is generally lost.

In the early years of my activities I found that certain artificials gave extraordinary results, but in later years, when plots have been put down, there was no appreciable difference. This rather surprised me, as I had thought that the milk and the grazing animals would have drawn on the phosphates.

After the temporary grass leys have been fertilised and trodden by stock, my methods for breaking it up are as follows. Using a big Diesel tractor on a 4-furrow plough, and attached to the plough is a land presser fitted with a seeding attachment, designed to drop the seeds (cereals) into the channels formed by the presser. Hitched on behind the presser is a flexible harrow—thus the land is broken, seeded and harrowed in one operation. Sometimes a second operation is necessary when the soil is on the heavy side. For those of us who use heavy tractors, it is important when ploughing ley ground or stubble, to finish the job if possible in one operation, because, first, the tractor will grip so much better on the firm ground, and the operation can go on, wet or dry. Secondly, the wheel marks are inclined to make the surface ' wavey ', and the land may be unduly pressed in some places, which often results in an irregular plant.

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Of course, if a track tractor is used, the one operation is not quite so important.

I find that the cost of ploughing with a big Diesel tractor is less than half that of a small paraffin tractor, *e.g.*, one man can operate a large tractor, using a 5-furrow plough, just as easily as he could use a small tractor and 2-furrow plough. Many of the small tractors use as much paraffin in a day as a large powered Diesel tractor uses crude oil—one is pulling 2 and the other 5 furrows.

I usually plough round the field, lifting the plough at each corner, and the headlands are ploughed afterwards. Thus in a square field, the headland would be like a X, all converging to the centre. I find many advantages in this system of ploughing.

1. There is a great saving of time.
2. The headlands do not get excessive treading.
3. In wet weather it is sometimes very difficult to do a half turn at each end of the field when the land is " greasy."
4. There are no deep furrows across the field, which is a great advantage when laying down to grass. I quite realise that in some cases water-furrows are necessary.

For breaking up stubble, I generally use a 10 ft. one-way disc plough—this is in effect, a large disc harrow, so constructed that all the discs are dished the same way. This is an excellent implement, and will make a good level seed bed at the second operation. When I start clearing my cornfields, I keep this implement working night and day, disking the stubble over to allow the weed seed to sprout before I give the second operation. I broadcast winter cereals, such as winter oats, and cover the seed with the disc. The criticisms I offer on this implement are first, it is difficult to operate from the driver's seat, and second, it should be provided with a seeding box.

Most of the peas and oats I grow, are made into stack silage, which is cut green, and swept immediately into the stack with sweeps fitted on cars using a stacker and motor sweep. This cuts out a lot of laborious work and uses much less labour. I also sweep all my hay and most of my corn with these sweeps. The men get very expert, when sweeping wheat from the stooks, they will carry the stooks in on the sweeps very often as they stand.
When sweeping loose barley, I have timed the stacker delivering loads on to the stack, at one every 45 seconds.

There is one thing that rather baffles me, and I wonder if any of you here can suggest a remedy ; it is the moss which appears most winters on some of my best grass land. It is not a serious matter because it quickly disappears as the spring advances. Where the moss grows the land is very calcareous.

I am afraid that I cannot describe my methods as well as I can demonstrate them. I want everything portable on the farm, and I want to decentralise as much as possible. I have very little use for permanent buildings.

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FARMING OF LIGHT LAND IN NORFOLK

By W. Parker
(*King's Lynn*)

When I received a request from Sir John Russell to read a paper on our farming of Narford Farm, in Norfolk, my first determination was to answer in the negative, as I did not feel I could write anything that would be of real interest to the agricultural community.

My life has been spent in real active and practical work, and I have had very little time to give to what I might term the "academic" side of agriculture.

When the letter arrived, I had staying with me three practical farmers from the counties of Leicester, Derby and Nottingham.

These gentlemen saw Narford Farm when we took it in hand and have visited this farm twice a year ever since, and to make a long story short, they prevailed on me to undertake the writing of a paper; in fact, they went as far as to state that, in their opinion, it was my duty to do so, as my experience might be helpful to farmers cultivating a similar class of land ; so, gentlemen, if my paper fails to interest you must blame them, not me.

I started my farming career in Leicestershire, but having read much about the wonderful work done in Norfolk by the great Thomas William Coke, First Earl of Leicester, of Holkham, my imagination was fired, and for years I had a strong desire to farm in that county ; and some sixteen years ago my desire was gratified, and with Mr. Richard Proctor of Spalding, as my partner, we embarked on our Norfolk venture.

As you are all aware of the hard nature of the times we farmers have been passing through, I will leave you to judge of the financial wisdom of such an undertaking.

Though I intend to deal more particularly with the Narford Farm, very similar methods are being adopted on some of our adjoining farms.

This farm is approximately 1,200 acres, and a big percentage of it had been allowed to fall out of cultivation. Many acres, called the " Sheep Walk," had never been cultivated, and was not reckoned in the tenancy.

This sheep walk was a mixture of gorse, heather, and bare-looking grass.

Many acres of the cultivated land was of such a light sandy nature that any winds would cause " blowing " of the sand, and very often would carry the seeds with it.

We decided largely to follow Norfolk lines, so started mainly with the four-course system, using artificials freely.

Unfortunately, potash was dear, and the dressings were not as heavy as we now know they should have been.

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We concentrated to a great extent on barley as a cereal crop and roots and seeds. Yields of barley, however, were low—not more than two to four quarters to the acre.

I might mention as a matter of interest that we tried the effect of ploughing up what I have called the Sheep Walk. The result was quite surprising.

We first took off a crop of barley and oats, followed by beet, then barley again, succeeded by another crop of beet, followed in some cases by a final crop of barley sown with long ley seeds.

We artificialled all these courses and were very pleased with the growth of a good quality herbage which is providing good grazing. A constant dressing of potash was given—kainit being preferred because of its salt content.

The old pasture land, of which there was about 120 acres, was given a dressing every third or fourth year, of 5 cwt. of kainit per acre.

It is close grazed with a mixed stock, including breeding sows. The close grazing has considerably improved it and it is surprising the number of stock it carries.

It is well harrowed with special spike harrows which remove the moss, and good ventilation is provided to the grass roots.

A splendid innovation on the part of the landlord (Admiral Fountaine) was the installation of hydraulic rams for water supply. The rams take their supply from the lake at Narford. Many miles of pipes were laid, and now water is supplied to an area of over 4,000 acres.

The great advantage of the ram system is that after the first cost of the plant and pipe lines, the cost of upkeep is small.

Admiral Fountaine has been personally responsible for many ingenious improvements in the system.

The crops were not improving to the extent we had hoped. kainit however, was becoming cheaper, and we increased the amounts to 3-4 cwts. per acre with 2-4 cwts. of superphosphate, according to the strength of the field.

Although ploughing deeper than most Norfolk farmers, it is only during the last three and four years that we have really gone in for deep ploughing, which has been attended with great success.

The deep ploughing has brought up the hard pan lying next to the chalk, and has also brought up the chalk.

Let us consider the land as it was :

It had a thin layer of cultivated sandy soil with a hard pan lying between this and the chalk bed. This small depth of sandy soil could not hold sufficient reserve of moisture, the hard pan preventing penetration, and owing to the light sandy nature of the soil, the moisture soon dried up. The breaking up of the hard pan giving a greater depth of soil allowed the moisture to penetrate deeper and provided a greater reserve of moisture.

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It is my opinion, also, that the hard pan has a lot of good nature in it, and being slightly heavier than the upper soil, increased slightly the heaviness of the sandy soil.

The most important factor was probably the effect of bringing up the chalk, thus providing the soil with the necessary lime.

This leads us to the question of the acidity of the soil, and it would appear that generally the soil needed correction in this respect.

This would partly be substantiated by previous poor results with the root crops, which apparently are more likely to be affected by acid soils.

There is, however, as one may expect, a great variation in the soils even in the same field.

I have with me copies of the analyses of some of the soils which I shall be pleased to show to anyone afterwards.

As regards roots, excepting for sugar beet, we soon found out they were not profitable, and have grown no mangolds or turnips for years.

Our first attempts at sugar beet were not very successful—the yields being not more than 7 tons per acre on the better land.

The effect of the deep ploughing is evidenced probably more in the beet crop than any. We have averaged up to 9 tons 18 cwts. of washed beet per acre—the poorest land averaging 8 tons 16 cwts.

After eating up the tops, our barleys were heavier than they were after swedes.

The barley yields have increased from 2 to 4 quarters per acre to an average on the total acreage of over 5 quarters.

Accompanying the deep ploughing, we broadcast before drilling 1½ cwts. of sulphate of ammonia, 4 cwts. potash (kainit) and 4 cwts. of superphosphate per acre.

There appears to be no doubt that more attention should be given by the farmer in studying the different degrees of acidity in the soils.

History shews that our forefathers evidently valued the importance of liming, as records show that great attention was given to liming. In the last 30 to 40 years, however, there appears to have been quite a decline in liming, probably due to economic reasons.

Dealing with recent work on the Narford Farm, the following is representative of the cropping records for the last four years :

Barley, barley, carrots, barley.
Seeds, barley, sugar beet, lucerne.
Barley, barley, sugar beet, winter wheat.

We have cut out the hay crop.

For the second time barleys, a dressing was given according to the nature of the soil.

Last year we made rather a revolutionary change, and put down on this farm 350 acres of lucerne, which is part of a total crop of 2,000 acres of lucerne on our three farms, Narford and the two

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Southacre farms, Hall Farm and Church Farm. These three farms being adjoining, are all worked together under the one manager.

The object of this large acreage of lucerne I shall refer to later.

The dressings for the lucerne land were :

1 cwt. Sulphate of Ammonia.
3 cwts. Superphosphate, 35 per cent.
2 cwts. N.A. Phosphate.
1½ cwts. Muriate Potash.

This gives a total of 7½ cwts. per acre. For the poorer fields the amount was increased to 8 cwts.

As lucerne requires a lot of lime, it was agreed that the soil with its chalk subsoil should prove very suitable.

The land was ploughed up to 14 inches deep and seeded last April and May.

A crop was taken from it during August and September, but owing to the exceptional drought the yield was very light.

Though a good part of the total 2,000 acres was seeded during a dry spell and has had very little rain ever since, the plant has become well established with a very even and thick growth, and there is every prospect of good crops next season.

The type of seed was mainly Hungarian, with a small amount of French Provence, all being inoculated.

I have been lately very interested in the question of young grass in connection with artificial drying, to which I shall refer later.

Investigations by Dr. Woodman and Professor Stapleton on the high nutritive value of young grass has shewn me that we have a fodder on our doorsteps which can replace to a great extent the expensive concentrated foods.

We have, therefore, seeded last autumn about 100 acres of Italian rye grass, and we have also about 70 acres of meadow pasture land which we are reserving for the same purpose.

The dressing we are using for the young grass is :

2 cwts. Superphosphate.
2 cwts. N.A. Phosphate.
2 cwts. Muriate of Potash.

This dressing was given in December, and was followed in the latter part of February with 1 cwt. of sulphate of ammonia.

A word on the implements we use will perhaps prove interesting.

We use Ransome ploughs fitted with broad skims. With these ploughs the top 3 to 4 inches of the soil, together with weeds, twitch, is carried to the bottom of the deep furrow and remains at the bottom, and thus has a certain amount of manurial value.

The light harrowing that follows fills in the crevices, preventing air getting down to the buried weeds and thus preventing their growth.

We are not believers of rolling on the light land under any conditions.

For deep ploughing we have found the Marshall Diesel tractors very economical, the fuel bill being very low. We also use them for

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threshing, and now have seven of these on our Norfolk farms.

For row crop work we use high clearance caterpillar tractors.

We have made a close study of hoes for these tractors, and have had hoes constructed for us by Ransomes which have proved very satisfactory.

For the cutting and haulage of the lucerne we use International tractors, the haulage tractors being fitted with pneumatic tyres. We are also using these pneumatic-tyred tractors for harrowing.

On the stock side the light land seeded to long leys previously referred to has proved first class grazing for cross-bred poll angus stock. These are grazing with North country breeding sheep and hoggets, commonly known as Massam.

We also keep on the older pasture lands a breeding herd of cows crossed with poll angus bulls and Lincolnshire cows.

Owing to the low price of beef, we have given lately more attention to pigs, and we have a herd of about 1,000 large black sows which we are crossing with large white boars.

We have erected near the water supply points pigsties constructed of pressed straw. The roofs, which are very thick, are made of hedge trimmings covered with straw and barley awns. They are cool in the summer and warm in the winter.

On the farms there are many old disused chalk pits, and we endeavour to establish the pigs near these as they form very useful shelter in summer and winter.

Turning to our harvesting operations :

Our harvesting methods are, I certainly think, more revolutionary than any of the operations on the farm.

The corn, immediately after cutting, is taken to the threshing drum standing in the corner of the field, and it is surprising how clean the damp corn can be threshed. From the thresher the grain is taken straight to artificial driers, of which we have three by British Crop Driers, Ltd., for whom Ransomes are manufacturing.

The driers are situated at central points, each drier dealing with the product of two or three farms. The damp grain is put through the drier, which is continuous in operation, and dried down to a safe keeping moisture content. The dried grain is in first class condition with a high germination.

From the drier the grain is delivered straight into a dressing machine, and then is either bagged or elevated to storage bins.

We have found this method of harvesting not only to be certainly expeditious, but it reduces the amount of labour and losses attendant on ordinary harvesting methods such as :

Losses due to shedding the grain when handling dry sheaves in the ordinary way.

No stooking of sheaves and the lowering of the quality of the grain due to exposure to the weather.

No heating in the stack and loss due to rats.

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No loss due to the top and bottom of the stack being damp, and, of course, there is no thatching.

A very important advantage is that we are able to work to a definite harvest programme without the costly delays one has to put up with due to our inclement weather.

Probably the most important factor is that as the grain is harvested and ready for sale in the one day, you can have your money in the bank instead of lying in the stack through the greater part of the winter.

There is a certain apprehension as to whether artificial drying affects germination. I can only say that with the type of plant we use, there is definitely no lowering of the germinating qualities and that it is quite common to have an increase of 1 or 2 per cent.

The straw, which is in varying stages of dampness is stacked in narrow stacks. The narrowness of the stacks allows the wind to get through and dry them out.

It is our intention to go a step further this coming harvest and try to do away with the self-binder which has been a valuable friend for many years.

Instead of tying the corn into sheaves we propose to elevate it loose from the cutter bar into trailers for transport to the thresher.

This type of drier is also used for the young grass to which I have previously referred so that the farmer is not only in a position to harvest his grain crops in good condition, but he is able to dry a product such as young grass and thus produce a concentrated food which our agricultural scientists confirm as being remarkable in all round nutritive value.

We have established the large acreage of lucerne to supply the South Acre Drying Station.

This drying station was erected last year for the production of Lucerne Meal.

The drying station is as near as possible in the centre of the crop to minimise the length of transport of the green crop.

The drying station is capable of dealing with 200 tons per day of the green lucerne which produces approximately 50 tons of meal.

The crop is cut with combine cutters and loaders, the crop being elevated straight from the cutting knife into trailers which are drawn alongside the cutting machine.

The trailers are fitted with pneumatic tyres and are hauled with the International tractors previously referred to. A trailer holds about three tons of green lucerne.

We estimate on getting three crops a year with a total life of 7 years.

I must ask your forgiveness in dealing rather at length with the harvesting side which perhaps is rather straying from the true subject of the paper, *i.e.*, The Farming of Light Land in Norfolk. As harvesting is, however, an important factor on the farm I can only hope my description of our methods has proved interesting.

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SUGAR BEET AND POTATOES ON A SUFFOLK HEATH SOIL

By A. W. Oldershaw, B.Sc., N.D.A.
(*County Agricultural Organiser, East Suffolk*).

The problem of poor light land engaged our attention soon after the war. Much of it rapidly became derelict. A great deal of what remained in cultivation was at an extremely low level of productivity Light land in a dry climate is in my opinion very unsuitable for grass. It may be sown with "grass" but what will it grow? Enough to keep a rabbit to an acre! Under lucerne, kidney vetch, sainfoin (if enough chalk is present) and certain clovers it is relaively productive but ordinary "grass" is in my view a mistake for such land.

We commenced the serious study of the problem of poor light land in October, 1925, by taking over 20 acres of land in the parish of Tunstall. The particular fields had not grown a satisfactory crop for at least three years, and were in addition, full of rubbish. The soil is a deep sand which will "blow" under certain weather conditions. One of the fields is named "Cow Walk" and my Chairman very aptly made the exclamation "Poor Cow"! when he heard this.

After consultation with Sir John Russell and the Rothamsted Staff we devised a roation and system of manuring which we thought might be suitable. It is as follows:

	Manuring per acre.
Roots, *i.e.*, Sugar Beet and Potatoes	3 cwt. Nitrate of Soda 3 cwt. Basic Super 3 cwt. Muriate of Potash
Oats	1½ cwt. Nitrate of Soda
Lupins	No manure
Rye	1½ cwt. Nitrate of Soda

The weakness of our rotation is that it does not provide any sheep crops. This however, could be easily remedied by a little modification. We could not rely upon getting a flock to fold our crops or we should certainly have made alterations with this end in view. On the two occasions when we have grown crops for folding, we have seen excellent subsequent results. We have proved that sheep are not essential, but certainly they are useful and prevent waste.

Our rotation, by the introduction of an area of lucerne and other herbage plants, would permit a good head of horned stock, pigs and poultry to be kept, with a few sheep.

I mention these points because I am firmly of opinion that one cannot consider sugar beet and potatoes only. They are merely parts of a general system, the object of which is to build up the

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fertility of the soil and in that means to grow bumper crops, to maintain a high output. The principal points in importance in attaining this object seem to be :

(1) To keep the land thoroughly clean and to till it according to the rules of good husbandry—efficiently and well.
(2) To use a rotation of crops suited for the soil.
(3) To maintain a fair head of live stock partly as a means of cashing unsaleable products.
(4) To apply suitable manures including where necessary, substances containing lime.

Tillage.

As far as the first point is concerned—we cannot afford to grow weeds—they take up plant food, space and moisture—none of which we can spare. Constant vigilance seems to be the only way to keep the land clean.

Tillage on a light sand is very different from what it is on clay.

I am greatly indebted to our foreman, Mr. G. Thurston, for his skill in cleaning the land ; which was in a very bad state when we first took it over. It is important to keep the rubbish on the top, on this soil. In preparing the land for roots we usually " rimple " immediately after harvest. Rimpling is ploughing with the breast off, and we usually go quite 10 in. deep. Then during the winter we rimple again, still keeping the rubbish on the top. The land is worked across in Spring, and if necessary the weeds are gathered and burnt. Then 10 days or a fortnight before drilling, the land is ploughed to a depth of 5 ins. to 6 ins. The interval between ploughing and drilling gives time for the seeds of weeds to germinate, these are killed when the land is harrowed before drilling. When we took over this land, a crop of spurrey as thick as the grass on a lawn invariably made its appearance soon after the last ploughing, but we have not now quite so much spurrey, especially on the chalked plots. We roll, then drill, then roll, and harrow.

Deep cultivation is very important to let the roots down to the moisture. If there is any sign of a pan, subsoiling should certainly be performed. After the land has been cultivated deeply for some years the depth of soil is increased and subsoiling probably need not be repeated continuously.

We drill our beet not very early, usually about May 1st., the rows being 17 ins. apart. In one or two seasons, where beet were drilled early on similar land and a cold wet spell followed, I have noticed they stood still and made very poor growth subsequently.

I like them to go straight on, without a check. We horsehoe as soon as possible, and chop out and single aiming at 5 ins. to 6 ins. between the beet.

Often we get a plant population of 45,000 to 50,000 per acre, we

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cannot grow large beet, therefore we must have a large number per acre. We grow Klein E. or Dobrovice.

We lift by hand, again not very early. The land is so light that it is not necessary to use a beet lifter and we have no need to worry about soil clinging to the roots, or about difficulties in carting the beet off in autumn.

Potatoes.

We have not experimented with farmyard manure and might very likely be able to increase our crop if we had some available. But we have none. We have grown Great Scot in the past but are changing to Arran Banner. Great Scot is a vigorous variey—which is what we want. We have tried Kerrs Pink, but I like Great Scot better. We do not want a delicate and small cropping variey. I may say, however, that we have not properly investigated the question as to what is the most suitable variety for our special soil.

The seed potatoes are ploughed in 4 ins. deep on the flat, after the two rimplings and cleaning operations as given for sugar beet. The width of row is 28 ins., two 14 in. furrows. The seed potato is put on the plough-wheel mark and is ploughed under.

In a dry season we do not ridge up. We get a few green ones but to ridge means to lose moisture and this we cannot afford to do.

The potato crop seems much more affected by drought than are sugar beet. In a year of sufficient moisture we get a good crop, but in very dry years such as 1929 and 1933 there is a great falling off, especially on the unchalked area.

Rotation.

Our first standard rotation was

1. Sugar beet and Potatoes.
2. Oats (January sown if possible).

We have not done well with winter oats. They seem to feel drought severely).

3. Lupins. These are essentially the one leguminous plant which will thrive on light land poor in lime. They may be ploughed in green, folded with sheep or harvested for seed. There can be no doubt that however they are disposed of, they greatly enrich the soil and their strong tap roots penetrate the subsoil, aerate, and in fact cultivate it.

4. Rye. Very heavy crops of this can be grown with the aid of nitrates. The grain is low in price but abundant straw is produced and the roots till the land. I think that all extensive root systems increase fertility.

Since the land has been chalked we have grown wheat with considerable success, also barley, peas, tares, and various leguminous plants, even beans.

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Fertilisers.

Very soon in our work, we found that the most serious trouble was lack of lime in our soil. The unchalked soil on the Heath Walk field had a pH. of 5.8 with a lime requirement of about 27 cwt. (the analysis being performed by Mr. F. Harey). Half of this field received a dressing of 5 tons an acre of chalk in the winter 1925-26. This lay on the surface of the ground and became thoroughly shattered, before being ploughed in. The rotation crops have been grown, in duplicate, on this field, over chalked and unchalked land for seven seasons.

The result has been a demonstration of the utter futility of trying to grow certain crops especially beet, on land lacking in lime and of the extreme ease and cheapness with which this want can be remedied when one is reasonably near a supply of chalk or other cheap source of lime.

The original cost of the chalk was 50/- per acre, including spreading and 4 years crops produced extra produce worth £18 on the chalked area. The results over a period of years, both for beet and potatoes are given in the following table :

Tunstall "Heath Walk."

The figures in brackets indicate the number of the entire plot (½ acre) in each year, half of which was devoted to Sugar Beet and half to Potatoes. The "Chalked" area received 5 tons per acre of lump chalk during the winter 1925-26. In all other respects the treatment was uniform.

Manurial Treatment both Sugar Beet and Potatoes— 3 *cwt. Nitrate of Soda* 3 *cwt. Basic Super* 3 *cwt. Muriate of Potash*	*Weight of Washed Sugar Beet per acre.*		*Average Percentage of Sugar.*
	Chalked. T. C.	*Unchalked.* T. C.	
1927 Plot (2)	9 14	Nil	19.1
,, (2a)	6 14	Nil	
1928 Plot (1)	13 6	Nil	21.3
,, (1a) ..	8 16	Nil	
1929 Plot (4)	10 16	1 1	18.3
,, (4a)	12 7½	0 14	
1930 Plot (3)	13 9	0 5	—
,, (3a) ..	11 8	0 3	—
1931 Plot (2)	12 10	Nil	18.0
,, (2a)	14 5	Nil	
1932 Plot (1)	17 7	4 3	18.0
,, (1a)	15 7	1 11	
1933 Plot (4)	13 3	0 12	15.7
,, (4a)	18 4	0 6	
Average Yield Per Acre	12 13	0 13	

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Potatoes

Note the effect of the dry years 1929 and 1933 upon the unchalked potatoes.

	Chalked T.	Chalked C.	Unchalked T.	Unchalked C.
1927 Plot (2)	13	4	10	5
,, (2a)	12	16	7	19
1928 Plot (1)	13	16	11	15
,, (1a)	12	7	10	1
1929 Plot (4)	11	10	6	2
,, (4a)	14	3	6	11
1930 Plot (3)	12	19	8	7
,, (3a)	12	4	6	2
1931 Plot (2)	12	0	9	7
,, (2a)	10	15	8	1
1932 Plot (1)	12	0	10	12
,, (1a)	12	2	10	5
1933 Plot (4)	10	4	4	14
,, (4a)	11	10	4	6
Average Yield per acre	12	5	8	3

In the case of sugar beet we also have the advantage of replicated plots conducted by Mr. Garner, Captain Gregory and the Rothamsted Staff, showing the influence of varying quantities of chalk. Ground chalk was applied on January 12th, 1932. The following is a summary of the results.

Tons per acre of Washed Roots

	No Chalk	*1 ton Chalk*	*2 tons Chalk*	*3 tons Chalk*	*4 tons Chalk*
1932	1.82	12.61	14.30	14.27	14.74
1933	2.94	11.40	13.23	13.26	13.91

Results, 1932. A large response to the first dressing of ground chalk. There is also a significant response to the sceond dressing. The sugar percentage does not appear to have been affected by the chalk.

1933. A large response to the lowest dressing of chalk applied in 1932 and a further significant response to the second dressing.

The sugar percentage was significantly increased by the first dressing of chalk, but not by further dressings. The yields on the the No Chalk plots represent carry over by the cultivation from adjacent land which receives chalk.

Potatoes. It is frequently said that the potato is a crop which does not require the addition of lime. No doubt this is usually true. But, especially in dry seasons, I think our soil is too acid even for the

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potato. Mr Garner reported on replicated plots in 1930 "Chalk appears to have no effect." Subsequently, however, he somewhat modified his opinion and regarded the line of demarkation between chalked and unchalked which I had observed, as evidence in favour of chalking. In 1931, with further replicated plots he again reported "The chalked half of the field did not give markedly different results from the unchalked."

This is, however, only two seasons. In dry seasons, especially, in my mind there can be no doubt whatever that chalking has increased our crops.

Moreover, especially in 1933, the effect on the size of the potatoes was remarkable, thus :

Heath Walk.	*Rotation Plots,* 1933. *Manuring Identical in other ways*	*Potatoes*
	5 tons chalk 1925-26	*Unchalked*
Plot 4	63% of ware	34% of ware
,, 4a	66% of ware	33% of ware

Cow Walk Nitrate of Lime Plots	*10 tons chalk*	*5 tons chalk*	*Unchalked*
	50% of ware	72% of ware	38% of ware
	65% of ware		27% of ware

In the very dry year of 1933, the haulm on the unchalked areas died down some weeks sooner than that on the chalked, in both fields.

Other plant foods. Sugar Beet.

In 1932, replicated plots, for which again we are indebted to the assistance of the Rothamsted Staff, showed :

	Tons of Washed Roots per Acre		
	No Super	*Super*	*Mean*
No Potash ..	16.81	17.52	17.16
Potash	17.62	18.05	17.84
Mean	17.21	17.78	17.50

The responses to potash and superphosphate are significant. The potash produced an increase of 0.22 in the sugar percentage which however is not significant. Superphosphate had no effect upon the sugar percentage.

1933. Replicated plots to test the effect of increasing quantities of nitrogen.

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Tons of Washed Beet per acre.

Uniform manuring	*No Nitrogen*	144 *lb.* *N. Soda*	288 *lb.* *Soda*	434 *lb.* *N. Soda*
3 cwt. Super 3 cwt. Muriate of Potash ..	13.17	15.04	15.91	15.92
Sugar	17.81	17.46	17.66	17.14

The difference between 15.04 tons and 15.91 can safely be regarded as due to the extra nitrogen.

It seems probable that the exceptionally dry season prevented the additional nitrogen on the plot receiving 432 lbs. of nitrate of soda from having effect.

Potatoes.

The Rothamsted replicated plots at Tunstall have shown a highly significant response to nitrogen, a significant improvement has been given by superphosphate and by sulphate of potash in presence of superphosphate. Previous experience indicated that nitrogen on this exceptional soil was the dominant ingredient, but evidently the other plant foods are necessary. The rather unusual combination of 3 cwt. of nitrate of soda, 3 cwt. basic superphosphate, and 3 cwt. muriate of potash, which we use as a manure for both potatoes and sugar beet ledge of the requirements of poor light land. It was only a guess. was due to our knowledge, or perhaps, I should say, our lack of know-

Even when no farmyard manure is used but only chemical fertilisers, there would appear to be a gradual building up of fertility in the soil. Time also would appear to be of value in allowing chalk to become thoroughly incorporated in the soil.

As evidence of the gradual increase in soil fertility I may mention that seven years ago we tried to grow sugar beet on the Cow-walk field. The resulting beet were most of them no bigger than a walnut —hardly worth lifting—and of a most peculiar shape—the roots being curved. Apparently the tap root would not face the acid subsoil. During the past three years we have had well over 12 tons per acre in the field, no farmyard manure has been used in the meantime

The replicated trials have indicated that after reasonably good treatment for several years, our soil responds to applications of phosphates and potash as well as very strikingly to nitrogen.

In some seasons we get badly dried up—notably so in 1933. In this case the tops of the beet died down and it looked as though the crop was worthless—but on lifting we were very agreeably surprised.

I may mention that with oats and wheat we have quite definitely come to the conclusion that it is not safe to use more than $1\frac{1}{2}$ cwt. of nitrogenous manure—more may do harm rather than good, in a dry time, and burn the crop up.

I should like to take the opportunity of thanking Sir John

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Russell, and the Rothamsted Staff for assisting us in many ways, especially for help in designing the experiments and in connection with the replicated trials. The latter have enabled us to speak more definitely regarding the requirements of the soil. Many others also have greatly helped us, especially those whose names I have mentioned and to whom thanks are due. In conclusion, I am making a claim, which I hope will be considered justifiable. It is that, even in the dry Eastern Counties, very light sandy soil of the heath type may be brought to a relatively high level of productivity without undue expenditure : by chalking where necessary ; by the use of a suitable rotation ; and by the aid of chemical manures adapted to the peculiar type of soil.

Given reasonably remunerative prices there seems no reason why such a system of farming should not be adopted wherever a similar type of land exists in this country. If this were done a substantial area would be added to the agricultural land of England.

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DANGERS OF DETERIORATION UNDER CONTINUOUS CROPPING

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The object of any form of agriculture is the obtaining of profitable returns from the land, while at the same time maintaining the capacity of the land for further production. Thus the question of the maintenance of the fertility of the soil is a fundamental consideration in any system of agriculture. And in England, on light land this has, in the past, been secured by two methods. In earlier days, the continuance of profitable agriculture was secured by frequent fallowing, and the old mediæval agriculture was based on a fallow every two or three years. Two hundred years ago, it was found possible to maintain the fertility, even of light land, without fallows, provided a suitable system of crop rotation was followed. The system of rotation usually adopted provided, on the one hand, a large amount of saleable produce, chiefly in the form of corn, and, at the same time, a sufficient amount of animal food to supply the material required by the animals employed to cultivate the land, as well as for the stock raised to sell as meat. The Norfolk four course rotation, either in the original or in modified form, did undoubtedly secure the maintenance of a high level of fertility even in light land, did provide the manure which was needed for the soil, and at the same time did enable the crops grown to remain normally in a healthy condition.

Recent developments in national economy have, however, made the old rotations no longer profitable and suitable over large areas, particularly in the light lands of the country. The demand for root crops for stock feeding has become reduced, and the rise of wages has led to a large increase of cost in producing them. The advent of the power driven machine in farming and of the motor on the roads has led to the decrease in the demand for fodders. The largely increased area under permanent grass has also added to the amount of fodder otherwise available. And, on the other hand, the supply of corn from other parts of the Empire and the World has removed the corn crops from the dominant position they formerly enjoyed, in the arable cultivation of light land in England.

The result is that over large areas, especially of light lands the old rotations have been perforce abandoned, and in hardly any region has any definite system of farming come to replace them. In some places, even, there has been a tendency to grow single crops year after year, with the application of artificial manures, or of other concentrated manures, either alone or in combination with farmyard manure. Thus, for instance, there are certain areas of

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light land, particulary suitable for potatoes, which have tended to be put under potatoes every year. Where things have not gone so far as this, there has been a tendency to use short rotations, consisting of marketable crops, and attempt again, to maintain the fertility by frequent and heavy manuring, with dung manures as well as artificials.

Such a policy is always dangerous, for if, for any reason, the supply of cheap manure fails, as has recently happened in areas which depended on London manure for their cultivation, the situation becomes very difficult, and the fertility may rapidly disappear, in spite of the use of artificial fertilisers. But even apart from such unforeseen circumstances, I want to show you to-day that all the evidence which is available seems to indicate that constant growing of one, or even of two, crops on light land, year after year, with marketing produce, leads to a falling off in the fertility, of light land at any rate, even when the amount of manure used is quite considerable. The experience of Woburn, where I am stationed, in this respect is very typical, and there may be advantage in calling attention to it.

The land at Woburn is a typical light loam, lying on the lower greensand, which furnishes so much of the light land areas in the Midlands and the South of England. For fifty years we have grown wheat and barley every year on such land, using large or medium doses of artificial fertilisers or of well-made cattle manure each year. The crops were grown every year from 1877 to 1926 and the manures were applied annually.The actual applications I shall consider to-day were those on five plots, as follows :

Plots 1 and 7.—No manure for the whole of fifty years. These show the falling off of the crops in the absence of any manure of any kind.

Plot 3.—Nitrate of Soda, at the rate of 2½ cwt. per acre from 1877 to 1906, and at half this rate from 1907 to 1926.

Plot 6.—Nitrate of Soda, at the rate of 2½ cwt. per acre from 1877 to 1906, and at half this rate from 1907 to 1926, with, in addition, Mineral Manures.

Plot 9.—Nitrate of Soda, at double the rates in Plots 3 and 6, with, in addition, Mineral Manures.

Plot 11.—Farmyard Manure, about 7 tons per acre from 1877 to 1906, and at half this rate from 1907 to 1926.

It will be seen that, on the whole, the amounts of both artificial and dung manures were high, at least during the first thirty years. The land was kept very clean, and yet in nearly all cases there has been a constant and almost steady decline in fertility, as judged by the crops obtained, during the course of the experiment. The following tables show this :

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Permanent Wheat

Plot	*Treatment per acre*	*Yield of Corn in Bushels per acre*				
		1877-1886	1887-1896	1897-1906	1907-1916	1917-1926
		bush.	*bush.*	*bush.*	*bush.*	*bush.*
1&7	No Manure	17.1	13.6	10.0	9.9	7.0
3	N.Soda, 2½ cwt. & 1¼ cwt.	24.1	23.2	17.0	15.1	13.3
6	N.Soda, 2½ cwt. & 1¼ cwt. with Mineral Manures..	32.4	30.1	23.6	17.5	16.1
9	N.Soda, 5 cwt. & 2½ cwt. with Mineral Manures..	37.2	30.8	29.2	18.1	15.2
11	Farmyard Manure. 7 tons & 4 tons	26.8	27.8	24.0	19.6	17.7

Permanent Barley

Plot	*Treatment per acre*	*Yield of Corn in Bushels per acre*				
		1877-1886	1887-1896	1897-1906	1907-1916	1917-1926
		bush.	*bush.*	*bush.*	*bush.*	*bush.*
1&7	No Manure	25.0	18.1	13.4	9.0	7.5
3	N.Soda, 2½ cwt. & 1¼ cwt.	40.4	30.9	23.7	15.2	11.3
6	N.Soda ,2½ cwt. & 1¼ cwt. with Mineral Manures..	46.0	41.1	35.3	19.7	16.8
9	N.Soda, 5 cwt. & 2½ cwt. with Mineral Manures..	53.3	45.3	42.9	25.4	20.0
11	Farmyard Manure. 7 tons & 4 tons	40.0	38.7	36.6	30.9	25.9

There are several points to which I wish to draw your attention in connection with the results shown in these tables. The first is that, whatever the manuring, in this light land, the yield of crop has gone off very greatly in continuous cropping. The loss of yield is much less where farmyard manure is used than where pure artificial manures are employed, as is shown by the following percentage losses, for the first twenty years, with heavier dressings, and in a second twenty years, with lighter dressings.

Percentage Reduction in Yield of Corn.

Plots	*Wheat*		*Barley*	
	In 20 yrs. *Per cent.*	*In 40 yrs.* *Per cent.*	*In 20 yrs.* *Per cent.*	*In 40 yrs.* *Per cent.*
1 & 7	42	59	45	64
3	29	45	41	78
6	27	50	23	63
9	22	59	21	62
11	10	34	8	35

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If these figures and the diagrams are examined, it will be seen that, in general, the percentage reduction in the yield of corn was not widely different with the artificial manures, whether mineral manures were added to the nitrate of soda or not, or whether the amount of nitrate of soda was doubled or not. In this case, it is clear that the falling off in yield is not due to a lack of manure but rather to something which prevents the manure added from having the expected effect. The effect is less in the case of farmyard manure than with any kind of artificial that has been used, and it is therefore, also clear that the use of dung has in part, but not entirely, avoided the influence which has destroyed the value of the manure added.

What is the cause of the loss of efficiency of the manures? I am afraid it is impossible to give an answer to this question at the present time. From our experience at Woburn, it would seem that some of the loss may be due to the increase of certain diseases as a result of constant cultivation. In the case of wheat, for instance, there is an extreme prevalence of the disease known as "take-all," especially on certain plots, The cause may, also, be partly found in the increasing difficulty of keeping the land free from weeds. This is always a great handicap under conditions where one crop is grown year after year, but in the present case, I do not think it has effected the matter much as up to 1926, very great efforts were made to keep these plots free from serious weeds. At the same time, certain treatments do encourage particular weeds, and the conditions of continuous cultivation prevent the cleaning of the land.

It is unfortunate that similar records do not exist for the long growing of other crops continuously on the same land, in the case of light land, for it is in some other cases that the temptation exists to carry on the practice. Thus, in one area of Bedfordshire, there has been a great temptation to grow potatoes year after year on land which is very similar to that at Woburn. In a few places the practice has been a success for a fairly long peroid, aided by the use of London dung and artificials. In other cases, the practice has led to very serious results. Eelworm disease has become prevalent, and the land has become incapable of growing a paying crop of potatoes. This has, I know, occurred at the same time as the supply of London manure has become smaller, and to this may be attributed some of the falling off of the health of this crop. But, in part, at any rate, it would seem to be the result of too frequent growing of potatoes on the same land. So far, in this case no-one has devised a method of getting over the damage done, except to leave the land free from potatoes for a number of years—for no available manurial treatment seems to be effective against the damage.

Other cases met with in practical farming might be multiplied. Perhaps one of the most striking is the case of sugar beet in Germany, where one of the limiting factors in sugar beet growing is again the

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eelworm which attacks this crop. It has not affected us yet in this country, but any attempt to grow sugar beet continuously or even too frequently on the same land, would be very liable to lead to serious results with this crop.

Disease and weeds are two of the causes of the falling off in the produce of land when a crop is grown continuously, but I do not think that this explanation covers more than a small part of the problem. In many cases these causes can be almost eliminated and yet the falling off with a continuously grown crop seems to occur, though, of course, not always to the same extent. The matter is obviously one for serious experiment, for if we could grow our valuable crops continuously on the same land, it would enable areas to be used much more efficiently than is the case at present. The problem is one which occurs on all land, but it is specially one which concerns the light lands of our country.

At present, the explanation evades us, and my object to-day is simply that of calling a warning against the idea that by the use of artificial manures or any other means, the falling off in value of continuously grown crops can be avoided. It is often, I know, a great temptation to grow a valuable crop very frequently, if not continuously, and trust to heavy artificial manuring to maintain the fertility of the land. This policy is definitely dangerous, and, if long continued, all the evidence available would indicate that the land will deteriorate in value.

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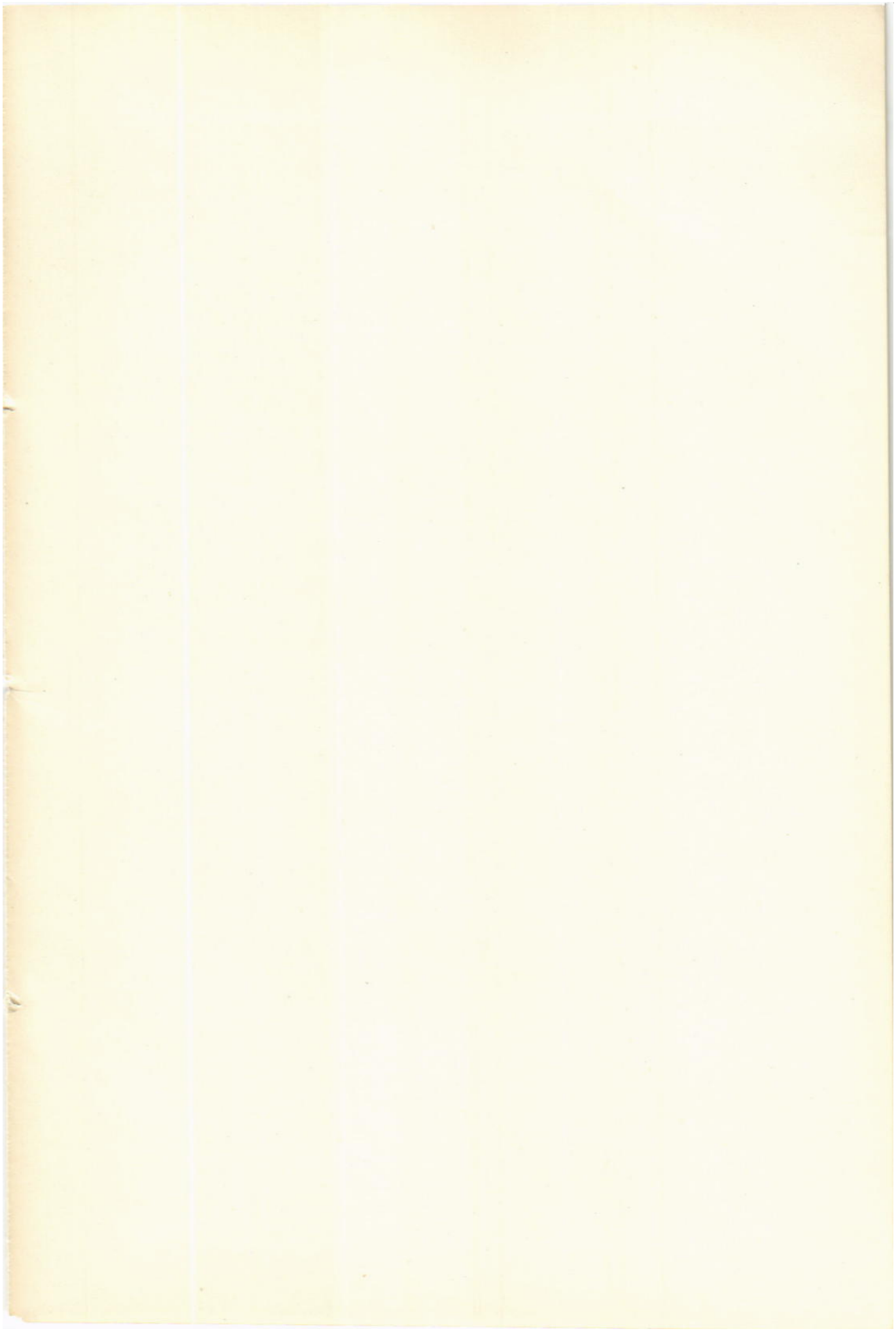

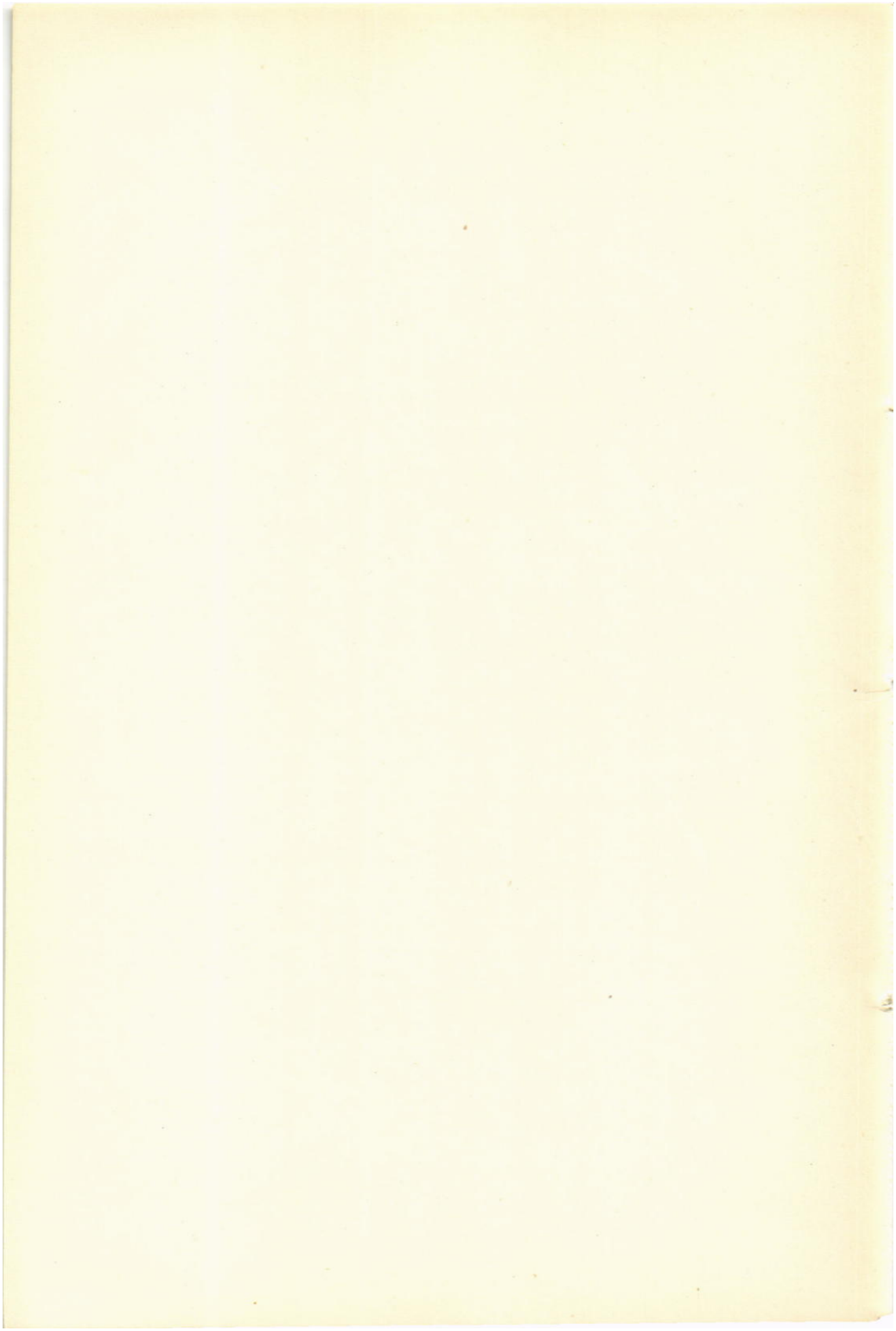

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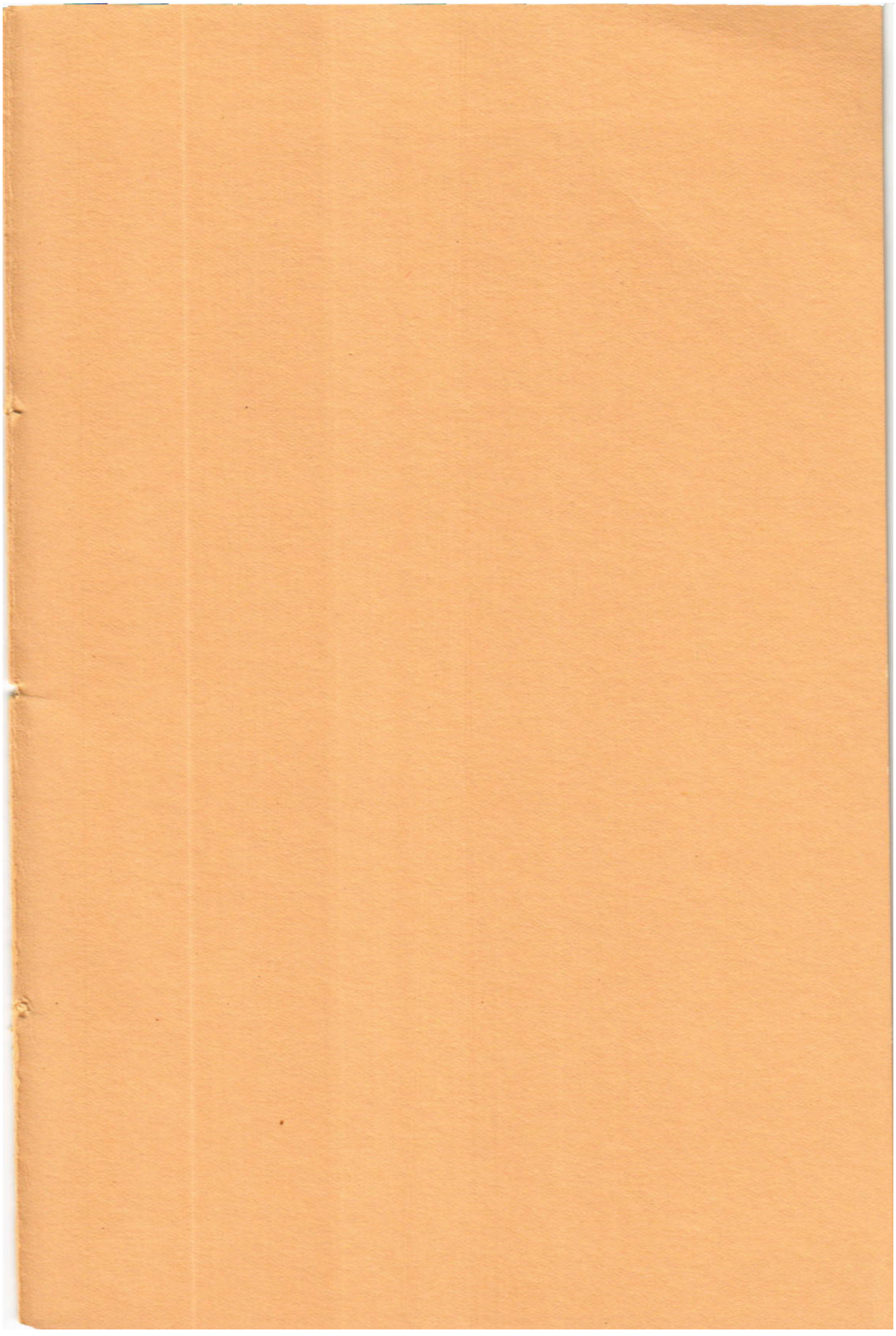

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