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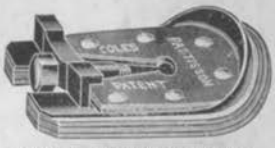

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Fig. 2 Welted Pattern.

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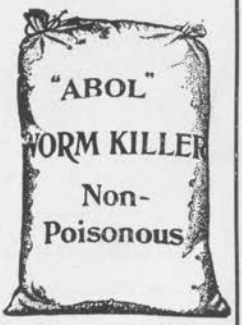

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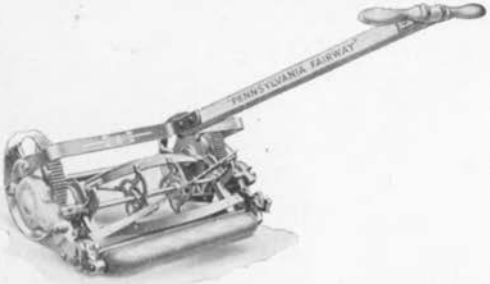

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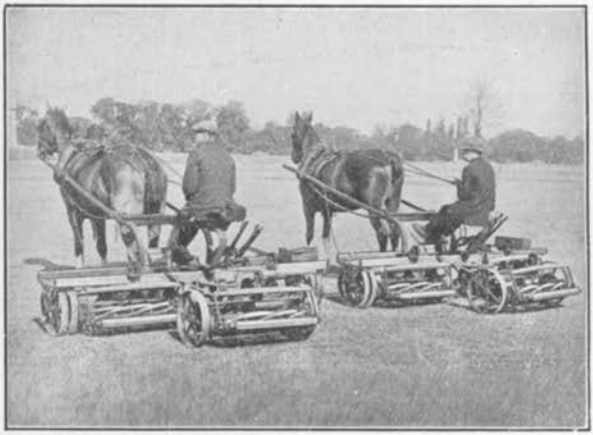

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THE JOURNAL

FOUNDED 1912

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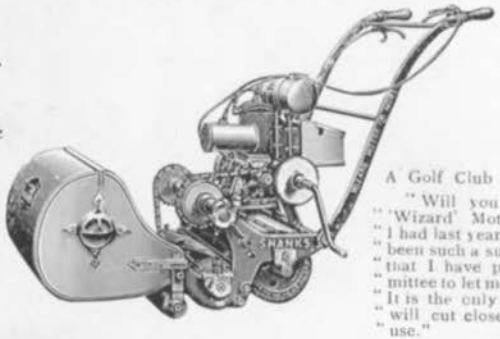

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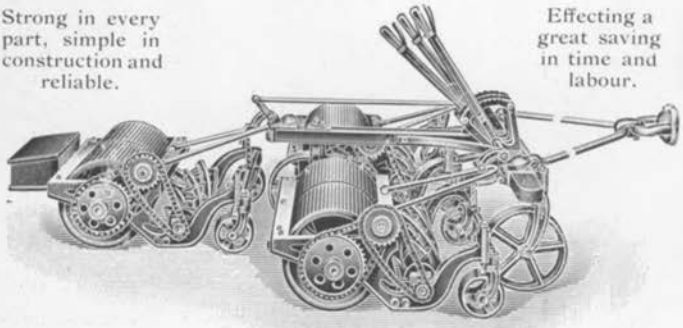

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Table of Contents.

FOREWORD.

THE Executive Committee have much pleasure in submitting to members another issue of the " Journal " of the Golf Greenkeepers' Association. With the ever increasing popularity of Golf and the corresponding increases in Golf Courses, this " Journal " will be very much appreciated by its members.

It is generally recognised that there is no better source from which Greenkeepers can derive such valuable information concerning their profession, and that no Greenkeeper can do without it.

In this issue are the reports of the various Lectures delivered to the members, by Mr. A. F. Wingfield and Mr. Watts, of Messrs. Sutton and Sons, Reading, and by Mr. R. Birch, of Messrs. James Carter and Co., Raynes Park. These should prove to be of considerable interest to members, more especially those who reside at too great a distance from London to enable them to get to the lectures.

There is also contained in this issue the whole of the prizewinning essays of the recent Essay Competition that was promoted by the Association, in conjunction with Messrs. Sutton and Sons, of Reading, who most generously provided the whole of the handsome prizes for this competition. These essays will be found full of information derived from actual experience, and should be of great interest and practical use to the members.

The Executive Committee are greatly indebted to those eminent authorities on greenkeeping, whose articles in the " Journal " add so greatly to its value.

A copy of this " Journal " is sent post free to every member of the Association residing in Great Britain, Ireland, and France, and wherever members are residing whose annual subscription is not in arrear.

It is used by members throughout the year as a book of reference, a fact which advertisers would do well to note.

The Executive Committee will not be responsible for the accuracy of the statements or conclusions contained in the several articles of this " Journal."

Any member willing to contribute an article on any interesting up-to-date greenkeeping subject, for publication in this " Journal," is invited to communicate with the Hon. Secretary.

Papers not used will be returned to the writers.

W. H. SMITHERS.

Golf Greenkeepers and Staff.

Owing to the large areas of the modern golf course, with its corners and out-of-the-way places where the opportunity for the slack man to do a quiet dodge is so often present, we all realise how necessary it is for the Greenkeeper to build up a staff of good, honest, conscientious workers, and, having them, to look after them in such a way that they in return will be always ready to do the best for him and for the Club who employs them.

There is, in the opinion of many Greenkeepers, room for much improvement in the relations between the Greenkeeper and his staff, and I venture to put forward a few suggestions for the consideration of those who may not have given the matter much thought.

The good Greenkeeper never loses sight of the fact that the successful working and upkeep of the course depends as much upon the staff as upon himself, and it is up to him to do his part in dealing with those under him. One hears occasionally of a Greenkeeper who has adopted the manner of the Kaiser, and fancies he is going to get the best out of his men by bullying methods; but sooner or later things are bound to go wrong, and the result will be serious trouble all round. On the other hand, where too much leniency and familiarity are practised the men get out of hand, and the course and everyone else suffers.

To be a successful Greenkeeper one must be above everything else tactful. He should know each of his men's capabilities and allot to everyone the job he is best suited for. At the same time I do not advocate the old-fashioned mehod of teaching a man one job and keeping him to it, for in my opinion every man should be taught another man's work, so that in case of emergency, illness, etc., there is always a man ready to fill up a gap. A Greenkeeper who has trained his men in this way not only rids himself of one of his minor worries, but is ready for an emergency.

It may be said that it is too difficult a task to teach every man another man's work, particularly when, at certain times of the year, every man has his own work cut out to get through his own particular job; but, my friends, you will find that if tactfully approached a man will always respond to your request to quicken up a trifle, when he knows that the time gained is going to be used to his own advancement and the good of the course. This, at least, is my experience, for I have always found my men keen in this direction.

My experience has taught me that, however big the staff, all can be made as one; this again by the use of a little tact. I have adopted in the ordinary work on the course a mild form of competition with the very best results, one of which has been to bring out the better man. This gives the man confidence in himself, and those not quite so good confidence in him. At the same time the Greenkeeper is in the position " of being able to select " his understudy without friction of any sort, which is certainly most desirable.

On the other hand I admit that without tact the result of such a competition might upset a whole system of good work.

One must be diplomatic in all things, strict with regard to timekeeping, as ready to play as anyone when the leisure time comes, but stern when necessary. Encourage your men by never failing to appreciate good work done. Such a policy, I am sure, cannot fail to give the greatest satisfaction to those who work under you and to the Club who employs you.

TOM F. MASON,

Greenkeeper, Hendon Golf Club.

Putting Greens and Fairways.

By G. SWINN.

MOST Greenkeepers will recognise the fact that there is some diversity of opinion on several of the subjects of this article. Practical knowledge teaches us to appreciate the fact that what may be right in one place is quite the reverse in another, where the variation in the climate, and local conditions, make a different mode of working essential. The rainfall, character of the soil and subsoil, aspect of the green, and many other items, must be thoroughly weighed before any given line of action can be given, and it is a sure thing that this is only known by the man on the spot. Therefore it is very difficult for a man at a distance to say what ought to be done and what ought not to be done. So I wish it to be understood that this little article is not meant as a hard and fast rule, because I know from experience that our ideas cannot always be carried out as we would wish, sometimes from financial reasons, or from lack of labour or materials, and various other causes. What I am setting down has been of use to me at different times.

GREENS.

To keep golf greens in perfect condition all the year round it will be admitted is a work of art. A knowledge of both grasses and soil is necessary before one can hope to make a success of it. To realise the difficulty one has to remember that golf greens are in play all the year round, a condition which does not apply to any other grounds devoted to games, consequently the structure of the soil and its mechanical condition are all-important.

Routine work may be roughly divided into two categories. One, which embraces mowing, rolling, weeding, and worm killing, has little or no direct bearing on the soil or its fertility; but even these simple operations have an enormous effect on the quality and condition of the turf, so that this work should be carried out with thought and care. The other category deals with the use of manure, top-dressing, and compost, and has a direct bearing on the conditions of the soil, both chemically and mechanically, and if the work is carried out properly a steady but sure improvement can be made to the soil, turf and playing condition of the greens at all times of the year.

If we accept in principle the fact that any deficiency of soil can be corrected in whole or part, a glimmer of light is at once seen. For instance, if soil is deficient in lime, the bulk of its chemical constituents are unavailable, and artificial manure cannot function properly; but as soon as lime is applied the fault is corrected, although its full effect may not be seen for a year or more. Sandy or thin soils lacking in humus are hot and dry, whilst heavy clays suffering from the same defect are poor, cold, and wet. Humus, decayed vegetable or animal matter, is the natural refuge for the beneficent soil bacteria, and can be added in the form of compost, and the balance of

the grass food made good by artificial manures. The mechanical condition of the soil can be altered by the application of sand, charcoal, and breeze.

COMPOST.

The preparing and mixing of composts forms one of the most important items in greenkeeping; but, although most of us realise the fact, one often sees this work carried out in a very careless manner.

To meet the requirements of modern greens the work should be carried out in a scientific and methodical manner, and, as the labour in preparing and the cost of material falls heavily on the finances of any Club where the greens are kept in good order, care should be taken to use only that compost or manure which may be expected to give the best results at a reasonable outlay.

To use manure in any quantity, because it has answered in another place, perhaps under very different conditions, is, to say the least, an expensive and at times a dangerous experiment. We know there are some well-known manures on the market which generally produce the same result under any ordinary conditions, and there are also some well-tried rules which one may observe to advantage in mixing and preparing a compost. One good way is to build up the heap to the desired size in layers, commencing with a layer of light sandy soil; if this is not available, the same result can be obtained by mixing sand and soil together. Next add a layer of well-rotted stable manure, and repeat until large enough. If the soil of the course is deficient in lime it should be added previously and never when mixing the compost. Always finish the heap with a good layer of soil, as this prevents the ammonia from being discharged in the air and thus lost. It is best, if possible, to make the heap on a hard surface; a concrete bed is fine, as one can have a well for the juice to run into. This can be pumped or thrown over the heap at intervals, and none of the goodness is lost. The liquid can always be used as a tonic for a green which has become run down. One very important thing to bear in mind is to see that the soil is light, To dress a green with anything like a heavy soil is to ask for trouble.

The heap should be turned once or twice during the summer. This should be attended to carefully, and the compost should be ready to use in twelve months. It is not a good plan to use it before, as there is always a certain amount of weed seed in the manure. When mixing, it should be cut down with a sharp spade and chopped up as fine as possible. It is a good plan to put it through a screen; if the heap has been properly attended to, it will pass through a ¼in. screen, if dry; if not, use a coarser one first.

The compost is then ready for use, and should be put on at the end of September if possible, as the rains will wash it in quickly. Rate, about 1 cube yard per 150 superficial yards; or in lighter Spring, Summer or Winter dressings reinforced with a small quantity of fertiliser.

It may seem strange to recommend the same compost for all classes of soil, but it is not if one realises that its chief function is to swamp and submerge the existing soil, whenever it is unsuitable, and replace it by one better suited to the requirements of the turf and to the game.

And now comes the question as to which artificial manure shall be used; for artificial manure (except in the opinion of a few cranks) is necessary to keep a green in good condition all the year round.

In preparing an Autumn dressing on light soils, potash should form one of the ingredients. If the soil is very light, muriate of potash is very good; if heavier, sulphate of potash answers very well; 20 lbs. of either to the cartload of soil is sufficient.

On some soils bone meal, at the rate of 1 cwt. to the load of soil, is a good Autumn dressing, but bones in any form are powerful phosphates and encourage clover, so must be used with caution.

On light soils, which are deficient in lime, a good dressing of gypsum or carbonate of lime is beneficial.

As a general rule, any of the less soluble manures should be used in the Autumn, the idea being to strengthen the grass after the trying summer, and nourish it through the winter months, and for this we want a manure which is slow in action, otherwise it would be forced at the wrong time, and in the Spring, when we wished to push it, it would be exhausted.

SPRING.

While the compost or basis of the mixture for a spring dressing remains the same, the chemicals composing it may be different. The Autumn dressing precedes a period of rest, the Spring dressing one of activity, and so requires a quick-acting manure to make up to the plant the wasted energy which is attendant or quick root action.

Guano is a splendid dressing on light soils, at the rate of 1 cwt. to the acre. It is rapid in action and fairly lasting. Pruvian guano is best.

Sulphate of Ammonia is usefully applied in conjunction with other chemicals in the form of compost; if used alone, a light dressing might be tried on a green which is run down, say at the end of the season. These light dressings ,are of the greatest use when given just when wanted, and as sulphate of ammonia is soluble and quick in action it is very well suited for this purpose; at the same time, when used alone it must not take the place of a regular dressing, but supplement it. A dressing of ammonia applied to a run-down green puts new life into it, but it should be followed by a more lasting mixture. The great difference beween a stimulant and a real dressing must not be lost sight of.

I always like to get my Spring dressing on as early as possible, so that if the grass does not respond there is still time to get another on before the hot weather sets in; and also it has a good chance to get washed in.

I think that most Greenkeepers have their own special mixture, so I don't think there is any need to say more on this subject. I am aware that there is much more to be said as regards the dressing of grass, more, indeed, than I should care to commence writing about.

FAIRWAYS.

When it comes to dealing with the fairways a little more discretion must be used as to whether a manure is wanted or not, and this can only be settled by a careful examination of the herbage. On the majority of seaside links the skin of vegetation covering the sand is very thin, and mostly contains more weed than grass, and usually a good deal of moss. This, no doubt, is due to the fact that the ground has been reclaimed from the sea at some time, and no depth of vegetable soil has had time to accumalate. A skin like this soon shows signs of wear, and easily tears up under an iron club, leaving a wound which heals very slowly.

The best thing to do in this case is a steady manuring of the existing vegetation; it is much better than letting it go until one has to returf, and perhaps with turf that has been brought from another and heavier class of soil. Nothing is more disastrous; it means that in time you will be left with a bare and muddy surface, whereas before you had at least clean sand.

By steady manuring with suitable manure, the existing grass will strengthen year by year until a respectable mat of roots is formed, and one that will stand a lot of wear, even in a hard season. Sometimes an attempt is made to improve the fairways by adding soil and farmyard manure. This, no doubt, is efficient in building up a soil, but it has drawbacks. For one thing, it is very expensive, as when one counts the time in carting, labour, etc., by the time it is spread on the course it will cost more than it is worth, and also it takes a considerable time to wash in, and at the best it tends to grow a fat, soft grass, more suitable for feeding bullocks than for playing golf. I have found Peruvian guano very useful for building up these kinds of fairways, and given at the rate of 3 cwt. to the acre it will show where it has been put to an inch.

A cheaper but at the same time very good dressing is to use basic slag and a good meat guano. This I have found very good on soil that is inclined to be sour. The basic slag should be put on in the winter at the rate of 6 cwt. to the acre, followed by the meat guano in February or March at the rate of 2 cwt. to the acre.

It is very seldom one sees a fairway being dressed. Even a dressing of sand makes a big difference, as it levels up the surface and adds a little carbonate of lime in the shape of broken shells, etc.

I have in mind several otherwise good seaside courses where the fairways are a mass of weeds, moss, and holes, and the only thing that seems to be done is to roll them, probably with the idea of flattening the surface. I am convinced that, with a good fertiliser, a covering of good grass could be grown on these fairways in time.

Important Notice.

THE EXECUTIVE COMMITTEE OF THE ASSOCIATION WISH TO MAKE IT KNOWN AMONGST ITS MEMBERS THAT THE WHOLE OF THE HANDSOME PRIZES AWARDED IN THIS ESSAY COMPETITION WERE PROVIDED BY MESSRS. SUTTON AND SONS, THE WELL-KNOWN SEEDSMEN AND TURF SPECIALISTS, READING, BERKS.

The competition proved a great success, very many entries being received, and the judges, Messrs. Bernard Darwin and A. C. M. Croome, had, we understand, great difficulty in selecting the prize-winners, the merit of all the essays sent in being extremely high. Following is the list of successful competitors:—

1.	W. KIRKBY	... Chantilly Golf Club.
2.	G. ALLCORN	... Holme Hall Golf Club, Scunthorpe.
3.	S. SELLERS	... Thanet Golf Club.
4.	G. KINNEAR	... Southerndown Golf Club.
(equal)	R. WILLIAMS	.. Rhyl Golf Club.
6.	R. HOOD	... Galashiels Golf Club.
(equal)	A. W. KIRKPATRICK	... Newbury Golf Club.

As the last two tied for the 6th prize, Messrs. Sutton and Sons awarded an extra prize, valued two guineas.

In addition, twelve "Awards of Merit" cards were given for the essays which were adjudged next in order of merit.

Our readers will be interested in the remarks made by Mr. Darwin, who in his report on the competition writes as follows:— "We have read the essays submitted to us with great admiration for the pains that the competitors have taken, the knowledge that they show, and the pride, pleasure and interest that they so obviously take in their work. There was a considerable number of praise-worthy essays, and the decision was not an easy one."

It is obvious that competitions such as this do much to stimulate the interest of Greenkeepers in their work, which is so essential to the well-being of the ancient game of Golf, and the Golf Greenkeepers' Association, as well as Messrs. Sutton and Sons, are to be congratulated on their enterprise.

Essay Competition for 1926.

By WILLIAM KIRBY,

Greenkeeper,
Golf de Chantilly
(Oise),
FRANCE.

There is no outdoor game played that can claim having its sites remodelled so many times as a Golf Course.

Fashions change so rapidly with the shaping and reconstructing of Golf Courses that the Architect and Greenkeeper have to keep advancing with the times.

Golf Courses that were considered good 10 years ago are completely out of date to-day.

Neither is there any game played which needs such exacting conditions for the upkeep.

Golf has now become so popular that Courses are being made on every kind of soil, and the Greens should be so constructed that a perfect sward of grass can be maintained which will withstand the ever increasing strain made upon them by play going on in every kind of weather, all the year round.

As this Essay Competition is for the construction of Golf Greens, Tees, and Bunkers, I assume that the plans and models have been made by an architect, and the constructional part is to be carried out either by a contractor or the Greenkeeper. In my opinion the Greenkeeper is the right person, but if it is done by a contractor, the Greenkeeper should have the overlooking of the work, because, if he takes an interest in his work, and as he will be responsible for the maintenance of the Course afterwards, he will see that only the best is put into the costructional part.

CONSTRUCTION OF GREENS.

There are two types of Green which the present-day architect favours.

The first one is that which is constructed so as to fall in naturally with the contour of the existing surroundings. This type of Green is fairly easy to construct.

The second one is artificially built up. This type seems the most popular to-day, although very costly to construct, and very difficult to maintain afterwards.

The construction of a Golf Green can be classed into five leading parts, viz., carting and labour, draining, top-soiling, manuring, turfing or seeding, whichever is decided upon.

CARTING AND LABOUR.

No construction work should be commenced until the Greens have been properly pegged out.

In the first type of Green it is necessary to peg out the Green only, as the Bunkers are usually made afterwards to define the position of the Green.

In the second type, it is necessary to peg out the Green first, and then the Bunkers and depressions before commencing, as the bulk of the soil will come from these to make the foundation of the Green.

Stout stakes should be driven in firmly at intervals from six to seven feet apart, to allow any vehicle which is being used in the constructional work to pass through them. These stakes should also vary in length, showing the rise and fall of the Green. Smaller stakes can easily be put in afterwards when the foundation of the Green is completed to show the exact contour of the Green for the work of top-soiling.

As the majority of Golf Courses are made on poor land, usually with gravelly, sandy, or stony subsoil, it is wise to reserve all top soil from the Greens, Bunkers, and depressions, storing it as near by as possible; this leaves a free hand for removing the subsoil from the depressions and Bunkers, to build up the Greens.

For preference, especially on heavy soils, waggons and rails, laid on planks, should be used, as when using scoops, with the horse constantly walking about the land, it gets solid; and if these rails are shifted systematically, and the work finished as it goes along, a great amount of time and labour is saved; each load is dumped in rotation, and spread evenly and trampled firmly, so that the whole will settle fairly level.

Special attention must be paid to this work, otherwise the Green will sink in one place and not in another; 10 per cent. must always be allowed for sinking.

No tree roots or stumps should be buried, as these gradually decay and the Green sinks, and no large stones should be buried, as the soil will naturally wash into the cavities and cause sinking in places afterwards.

When the foundations of the Greens are completed, and the shape and size of the Bunkers are obtained, the work of draining and laying on the water should be carried out.

All soils are improved with drainage, and if a green is to be kept in good condition water is a necessity, especially on raised Greens, as the banks and slopes of the Green are so exposed to the drying winds and sun that the outsides of the Green get quickly scorched and dried up.

At this stage of the work one is able to see the best position and height for the hydrant. These must be level with the surface of the Green when the work of top-soiling is completed.

DRAINAGE.

No hard and fast rule can be laid down for the method and system of draining, this must be dealt with according to local conditions and the nature of the soil to be drained.

When all the pipe tracks are laid, the trenches should be filled with large clinkers, stones, or anything that will allow water and air to pass through quickly without choking.

The whole of the surface should then be dug over, and on heavy soil about three or four inches of clinkers spread evenly over the surface; this allows a free passage for the water into the drains.

The points of good drainage are as follows:—

Soil in its natural state is possessed of capabilities which practically lay dormant until the land is drained.

One may ask the question, " Why does drainage improve the soil and promote healthy growth of vegetation?" In undrained land the level at which the water lies is sour, acid, and stagnant, therefore only the roots of coarse grass and weeds will penetrate into it (hence my previous remarks *re* the breaking up of the foundation of the Green before top-soiling). Also, when too much water lies in the surface soil the food that is absolutely essential to plant life is so acid that the roots of the fine grass, which has no power of selecting food material, absorb this sour matter until the plant is practically starved.

The access of air is also necessary to fertilize the soil, the air following through the water channels. Air cells or chambers in the soil on drained land allow substances which fall from the air, and which are Nature's benefit to plant life, to be carried down to the roots with each shower of rain, whereas on undrained land the cells are closed, the soil become sour, and the fertilizing substances simply run off the surface with the rain.

As an example, take snow, which falls in equal thickness; it dissolves more quickly on drained land (especially over the drain) than undrained land; this proves that the land is warmer where the air has been admitted through drainage. Stiff and clay soils are made more friable and the soil is made more porous, therefore all

the warmth of the early spring sun is able to penetrate into it, producing an earlier growth of grass, which is most valuable on a Golf Green. The vegetation withstands drought better, as the porous nature of the soil allows the roots to go deeper in search of moisture and food. Lime, compost, and manure have a much quicker and better effect.

TOP-SOILING.

When the work of the formation of the foundation of the Green is completed, permanent stakes should be placed in position showing the contour, also the undulations. If the Green is terraced, the outlines of the terrace should be staked out, and finality spelt before the work of top-soiling is commenced.

To avoid confusion, soil can be graded as heavy and light. Now soil, either light or heavy, whether the top soil has been reserved from the Green or whether imported for the purpose of top-soiling, can be deceptive. Spread this evenly over the surface the desired thickness, admit air, and usually the result will be you will find it green over with weeds in a very short time. Weed seeds have great vitality, and are capable of lying dormant under the soil for a considerable period until exposed to air and warmth.

Too much attention cannot be paid to the work of top-soiling a modern Golf Green, and to-day there is a fine opportunity for anyone who can invent a portable apparatus for sterilizing and cleaning soil at a cheap rate. One may argue the point that by sterilization some ingredient of the soil which is essential to the life of the plant would be destroyed. Against this, as soil only holds the plant in position, its food being obtained from chemical substances in the soil, others falling with each rain, any other necessary nutriment which the plant requires could be applied at the proper season, and a healthier sward of grass could be maintained by this method.

The work of replacing the top soil should be done methodically, and no matter what method is adopted all transport should pass over wide planks, these gradually being withdrawn as the soil is built up and levelled to the height of the stakes, and no heavy traffic should be allowed to pass over the newly placed soil.

Not less than six inches of soil should be put in the lowest places, while twelve inches should be allowed for the highest part of the undulations, as the highest points are liable to scorch during hot weather unless the roots can sink deeper, and no matter what top dressings are used the greatest part will find its way into the depressions.

The work of top-soiling being completed, the whole should be forked over, leaving it rough, and at the same time remove any foreign substance in the soil.

MANURING.

At this stage a dressing of lime shold be given in quantities to suit the soil. Lime is not a manure, but is a necessity for the fertility of the soil; no soil or any manure put into the soil is complete without its aid, and it is useless to attempt to grow perfect grass without lime. It is a wiser plan to incorporate lime at this stage than later on, as if sown on the surface it has a tendency to produce clover. A fortnight after liming, the soil is in a fit state for manuring. On light or sandy soils cow manure, especially if bedded with peat moss, is best, being cool and lasting. On heavy soils, short horse manure is the most valuable, as this land is cold and needs warmth. Not less than twenty tons per Green, say thirty, yards by thirty, should be used. The manure, no matter what quantity is used, is best applied at twice; half the quantity should be spread evenly over the surface and lightly forked in, but no more than four inches deep. A month later on, the remaining half should be spread in lightly forked in the same depth; this ensures the whole being incorporated with the surface soil of the Green and enables the roots of the grass to obtain full benefit of the manure as soon as root action commences. When the second application of manure is dug in, the ground should be left rough as dug to allow the land to weather, and, if possible, the manure for this purpose should be stored one year in advance.

On clay soils, dressings of coke breeze, small clinkers screened the proper size, should be mixed with the soil at each digging; these will gradually eat into the clay and keep the pores of the land more open and give the roots of the grass an opportunity of working freely.

Heavy and sour soils are greatly improved by adding charcoal. Charcoal is lasting and keeps this class of land sweet, it being an absorber of moisture, and also keeps the land from caking. Charcoal burnt from oak or beech is best for this purpose; charcoal made from from other kinds of wood has no lasting qualities and very quickly disappears. Pieces about one inch in size should be used; if larger, the Green is often broken up when cutting a new hole on the Green, from one to two tons per Green should be used according to the nature of the soil.

On sandy soils no sand is needed; on light, medium, heavy, or clay lands dressings of fairly coarse washed river sand should be given before the first raking. Sand should never be buried deep, as sharp sand will work its way into the soil, which it opens up, and at the same it time helps to fine down the grass, which otherwise, with the manure being so close to the surface, would have a tendency to become coarse. If possible this work should be completed six to eight weeks in advance; this gives the land a chance to consolidate, and also allows for time to get rid of the weeds.

When the ground is required it should be trodden, raked, trodden, and raked again until the surface it quite firm and true and a fine tilth, and barely shows a mark when it is walked upon. I prefer trampling and heeling for Golf Greens because then every part of the surface is made solid. Finally, pass a roll over the whole of the surface, and if the whole of the roll touches the surface the Green is true and any small depressions are easily seen and levelled. The whole is then ready for seeding or turfing, whichever is decided upon.

SEEDING AND TURFING.

The question of turfing versus seeding has to be considered. One has great difficulty in obtaining good turf containing the right species of grass most suitable for a Golf Green, but if turfing is absolutely necessary prepare a piece of ground and sow with a mixture of the finest grass seed beforehand. In seeding only buy mixtures of grass seed from a well-known house with a good reputation, as these firms will usually give a guarantee with their mixtures.

In conclusion, the main points in the construction of a Green are: The surface of the Putting Green should be sufficiently undulated to make them interesting, and all undulations should be long and rolling so that a mowing machine can work without skimming the ridges and be able to mow out the hollows without leaving long grass; three-quarters of the Green should be available for placing the hole, and any hole cut should have a level putting surface of not less than four feet round it.

THE CONSTRUCTION OF TEES.

The Tees on an average Golf Course get more hard wear than any other part of the Course, and until recent years they received the least attention.

The construction of a Tee is of as much importance as the construction of a Green, and no amount of top dressing will produce a good Tee which will stand the hard wear without a proper foundation.

To illustrate this: The Turf on the Tee should be composed of a hard deep-rooted grass that will stand cutting of ordinary divots and recover, therefore a foundation should be made which will encourage the roots to go down, whereas if a Tee is only top dressed the roots quickly come to the surface and each divot made is disastrous.

First, the Tee should be staked out, the greatest care being taken to see that the Tee faces the Green. This work is best done by laying a line or cord each side of the proposed Tee; if the line on each side of the Tee covers each side of the Green the Tee is in the proper direction with the centre of the Tee facing the hole.

Tees on a sandy soil should not be raised unless for a special purpose, such as getting a level surface or to obtain a better view

of the Green. Owing to the dry nature of the soil the Tee should be dug out to the depth of eighteen inches; the bottom six inches should be filled with old broken turf and small clinkers equally mixed, the remainder should be filled with equal quantities of natural sand, good loamy soil, and well-decayed manure. Trample well until firm.

Tees on heavy soils are most difficult, as these are on inland Courses and are used all the year round. To ensure being good, Summer and winter Tees should be made. The construction of both is practically the same.

Summer Tees should be level unless needed for a special purpose.

Winter Tees should be raised.

First take off the top soil, then dig out the subsoil to a depth of two feet, fill up with one foot of stones, brick rubble, and clinkers, covering these with a good layer of small clinkers to prevent the soil working through. The remainder should be a mixture of good soil, well-decayed manure, small graded clinkers, and sharp washed river sand, the whole well mixed until the soil remains firm yet porous. Should the mixture be light, add more soil until the desired firmness is obtained, because if the soil gives way with the pressure of the foot the Tee will quickly wear out.

Winter Tees should be brought up to ground level with clinkers, stones, etc., for drainage; the soil above ground level should be about ten inches deep and the same mixture as above; the slopes should be long and irregularly made, thus avoiding all squareness.

Tees should always be turfed with a deep-rooted, hard-wearing grass; this is usually found by the side of roads or footpaths. Good grass mixtures are now sold for this purpose but it is advisable to sow it in the grass nursery, and let it remain for two years before using, so as to get well established.

Tees for short holes should be larger than ordinary Tees, to allow the box to be changed oftener on account of deeper divots being cut out and taking longer to recover.

Winter Tees should be set at different angles, and never in front of the Summer Tees, to avoid being walked over.

THE CONSTRUCTION OF BUNKERS.

No general rule can be laid down for the construction of Bunkers, as the natural undulation of the land and the nature of the strata of the subsoil have to be taken into consideration.

Every description of Bunker, whether the sunk Bunker, or hump or hollow, can be more easily made on a new Course under construction than on an existing Course, because so much turf has to be taken up on an existing Course to get the desired natural effect, and more especially on a flat Course.

In modern Golf Course construction there are two varieties of Bunker, the sunk Bunker with a bank at the back, and a hump or hollow; both of these should be made to look as natural as possible.

In the sunken Bunker with a sand face and bank at the back, the exact shape should be staked out, then the soil from the Bunker should be thrown out to form the bank. The entrance to the Bunker should have so long a draw into the Bunker that it is hardly noticeable, and finishing at sand level. The deeper the Bunker the longer the draw. This makes the Bunker look more formidable, as more of the sand face can be seen from a long distance; it also gives more soil for the bank at the back. The face of the Bunker should be fairly steep, with tongues of rough grass running down the face in different shapes and at different angles, forming irregular patches or pockets into which the sand should be thrown up as high as possible, the sand sloping gently into the centre of the Bunker as if blown there; this gives a better effect, and the ball rolls into position for play. The tongues of the turf serve the double purpose of breaking up the long straight face and allowing the player to walk up instead of climbing up the sand face. The backs or banks of Bunkers should be long and irregularly shaped, merging into any natural contour of the surrounding ground and dying gradually into the level land. Re-turf with rough turf.

In the construction of these bank and hollow Bunkers let your imagination take you to the seaside, where you see mounds and banks which have been tossed by the elements, thus exposing the sand under an irregular overhanging lip, with a heavy moustache of rough grass.

All straight lines in these Bunkers should be avoided, as they give such an artificial appearance.

All natural banks, mounds, hillocks, on the Course or on the side should be taken advantage of wherever possible; hollows should be broken into them for sand, and every hollow should be a different shape from its neighbour, always bearing in mind that the hollow or pocket farthest off from the line of play should be the most difficult.

In shaping out Bunkers from the hillocks and mounds, do not cut with a sharp-edged tool, but break down with a fork or drag so as to leave a broken edge.

It is useless to dig deep Bunkers on land which is waterlogged in winter, as nothing is more objectionable than to find one's ball lying in stagnant water. This difficulty is overcome by making humps and hollows; any old tree roots, stumps, or large stones can be utilised for this purpose, placing them at irregular distances and various heights, covering them with roughest turf. When the soil has sunk into the crevices of the roots and stones, they usually give the effect of a natural mound. The depression should be filled to ground level with sand.

In the construction of any Bunker always bear in mind the

player, and do not construct any fancy nooks or corners where it is impossible for the player to use his niblick to play out.

THE MANURING OR FEEDING OF TURF.

Opinions differ very much on the question of manuring turf, and one has to solve the problem by asking another question: Do we manure the turf direct, or do we manure the soil in which the turf exists?

My answer to the first question is: No; we manure the soil. Practically everyone has sufficient knowledge to know that soil is not dead, as was generally supposed years ago. It is alive. Soil is composed of living germs known as bacteria, and must be treated with all the thought, care, and attention which all living things require if the best results are to be obtained, as it is through bacteria that mineral substances are dissolved with water for the fertility of the soil and made ready for the roots of plant life to absorb.

What is fertility of the soil? The fertility of the soil depends mainly in the method of supplying minerals necessary for the existence of plant life in suitable state and in suitable quantities. To supply these we have the option of two manures: 1. Organic or natural manure, which is practically a complete manure. 2. Inorganic, chemical, or manufactured manure.

All kitchen and flower gardens and farm lands are manured periodically with organic manure, as this can be dug or ploughed in. With turf this is impossible; hence the necessity of putting organic manure under the turf, because when once a good sward of grass is obtained organic manure can only be used in a prepared state known as compost, in small quantities.

Lawns and other turf are mown closely three or four times per week during the growing season, and the mowings are collected and either thrown away or placed on the manure heap to decay and be used elswhere. If this practice is continued for long and nothing returned in the shape of manure, the drain on the plant food of the soil is so great that eventually the finer grasses get completely starved and gradually die out.

The principal necessary foods for plant life, or the three which are the quickest taken off with the crops, are Nitrates, Phosphates, and Sulphates, to these three Lime must be added. Lime in itself is not a manure, but it corrects the acidity in the soil, and by removing the acidity of the soil it has the effect of preparing all available plant food in the soil by assisting the development of those bacteria which convert the organic matter of the soil into soluble plant food.

Organic manure, before being ready to apply to the turf, must undergo a process of decompostion and fermentation, so compost heaps

are made for that purpose. Everyone who has the upkeep of turf knows the value of a good compost heap.

Before describing the making of compost heaps, a few words on manure for this purpose might not be out of place. The excrement from different animals and the litter employed for bedding them possess special fertilising properties for different soils. For ordinary purposes farmyard manure is best mixed together, as then the largest number of different constituents are included.

Manure for turf should be selected for the nature of the soil where the turf has to be fed. Horse manure, being of a hot and dry nature, is best suited for medium or heavy soils; cow manure is cold and slower in action, and more suitable for light and sandy soils. The urine of animals has as much of if not more ammonia and nitrogen than the solid excreta; hence the necessity for bedding animals with litter that will absorb the most urine. Peat moss comes first in this respect; dried leaves and bracken comes next, only bracken has one drawback, the stalks are too slow in decaying; barley and oat straw are next, being soft and absorbent; while wheat straw, although the most durable for bedding purposes, has the least power of absorbing urine. In storing away manure for manuring turf, the least litter possible should be employed. Manure from the female, either horses or cattle, is more valuable than the male, as the excreta is soaked in urine. As a simple test, this can be proved with horses. The manure from the female is no use for growing mushrooms, as the ammonia from the urine is so strong that it kills all the spores of the mycelium; so in stacking up compost heaps one sees the necessity for using the best, and in the moss litter, where the urine is retained, we have the best for this purpose.

So much has been said about compost heaps that a long account is not necessary. If a proper place is not available with a cement bottom, prepare a piece of ground sloping gradually to one end, and puddle the bottom with clay until solid, so that all liquid will drain into a hole dug at the lower end. The size of the heaps should be about 10 yards long and two and half to three yards wide. This is the most useful size.

In building up compost heaps with manure, if leaves or leaf mould are obtainable, place a layer of leaves or leaf mould, a layer of manure, and a layer of soil or old turf if possible, taken from the same land where the compost is to be employed. Keep building up until half the desired height is obtained, then spread a layer of sharp sand about three inches thick; then continue building up as before until about five feet high. If leaves are used instead of mould, trample firmly, and make six feet high to allow for the leaves sinking. Cover the whole with a thin layer of sand, and finish off with good layer of soil to retain the ammonia. Sand is of no manurial value, only when the heaps are broken down the compost screens more freely. The liquid draining from these heaps can either

be utilised for liquid watering, which is very suitable at certain times of the year, or the hole can be emptied periodically and the liquid thrown on to the top of the compost heaps. These heaps should be turned in about six months, turning the outsides into the middle. This admits air and assists decomposition. The whole should be ready for screening in about twelve months—the fine to be used for top dressing the turf, the coarse to be built up into another heap for future use. Never mix lime in compost heaps. Three cwt. of agricultural salt will greatly improve them. The fine screened compost is best known as humus, which is not only a complete food in itself, but consolidates a light soil and makes a heavy soil more porus.

Rape meal is waste product from oil cake mills, and contains valuable organic matter. It is nitrogenous in action, and can either be used separately or mixed with other fertilisers at any seasons of the year. It may be used on young grass with safety, and it is equally as valuable on turf owing to its lasting qualities.

Peruvian guano is the excreta from sea-birds deposited on the tropical sea coasts of America and Africa, and as these are practically rainless countries no fermentation has taken place. It contains all three elements for grass life and is a complete fertiliser in itself. It should be used with caution, applying only small quantities at any one dressing mixed with equal quantities of fine soil. It is best watered in as soon as it is sown, because when coming into contact with water the nitrogen is quickly released and available to plant life at once. It should always be passed through a fine sieve before using.

Poultry and pigeon manure when allowed to dry in an open shed may be used with advantage on turf; and, although not on the market commercially, the manure from poultry fed on dry food is most valuable. It should be applied sparingly owing to its hot and fermentative nature, and is best applied in a fine state and watered in at once.

Night soil is a powerful organic manure, but is seldom used on account of its offensive odour. If prepared as a compost it should be mixed with fine charcoal or fine dry earth before using. I have found it very good for heavy soils by burning, and top dressing the turf with the ash.

INORGANIC MANURES.

These can be classed under the headings of Potash, Phosphates, and Nitrogens, or manufactured manures.

Potash manures should never be used on Golf Greens, as, although they increase the herbage, they have, with their fellow phosphates, a strong tendency to produce and encourage clover.

Kainit is about the cheapest form of potash, and if mixed with basic slag and sown in the Autumn will greatly assist the growth of herbage on a poor Fairway, but should never be sown near a Green.

Sulphate of potash is a purified kainit, and can only be included in mixtures where potash is needed in the soil.

Wood ash was greatly in demand at one time, but owing to its richness in potash it is only valuable to plants or soils requiring this element.

PHOSPHATES.

Superphosphate is a manufactured article, and may be used on land which is deficient in lime, and is best applied in the Spring if mixed with sulphate of ammonia. It should be watered in immediately after sowing, as it is apt to burn.

Basic slag is the bye-product in the manufacture of steel. The phosphorus, which is an impurity of pig iron during its conversion into steel, combined with lime, rises to the surface of the molten metal and is poured into moulds. Its value depends on the fineness to which it is ground, and it should be classed as a store manure, as grass can only assimilate about a third of the phosphoric acid in basic slag in each season. It is best adapted to strong lands deficient in lime, and is best sown in the Autumn, and should never be allowed to blow on to a Green.

Bone meal or bones contain a larger percentage of phosphorus over nitrogen. It is very slow in action and encourages clover.

Steamed bone meal is the ground residue of bones, after the fat and gelatine have been obtained at the glue works, and is the best to obtain if one mixes their own manures.

NITROGENOUS MANURES.

Nitrate of soda or Chili saltpetre is imported from Chili. This is the most rapid in action of the nitrogenous manures, but cannot be recommended for Golf Greens or good turf. Owing to its highly soluble nature, it cannot be retained in the surface soil, therefore it has a tendency to promote deep-rooted and coarse grasses.

Sulphate of ammonia is obtained from gas works as a bye-product in the manufacture of gas. It is the best of the nitrogenous manures; it encourages grass, and discourages clover. A rich growth of grass with a good deep colour usually follows a dressing of this manure. A great controversy is being debated on the merits of sulphate of ammonia at the present time. When being employed by itself, it tends to cause acidity in the soil, but against this, the grass is kept finer, and the soil more free from weeds.

Dried blood, or blood manure, is extremely rich in nitrogen, but the chemical composition varies according to the different

animals from which it is obtained. It is perfectly safe to use on practically every kind of soil in the Spring.

Soot has valuable fertilising properties, being nitrogenous in action. The one great objection to its use on Golf Greens is the discolouration of balls; but if a Green is rested in the Spring, or Winter Greens are used, I strongly advise a dressing of soot in the early Spring, as apart from its manurial qualities it materially helps to keep down the larvæ of destructive insects on grass.

Malt culms.—These must not be confused with malt dust; malt culms are the roots of the finished malt, which are broken off with screening. Malt dust is the small pieces of roots and dust which filter through the holes in the floor of the kiln, and, falling on the top of the dome of the furnace, they are impregnated with the fumes of either coke or anthracite. Malt culms are the more valuable on young grass, because they lie light, and assist the grass to braid and form a thick mat. At the same time, during decay, they form a valuable manure. Malt dust is more suitable to well-established turf, and, if possible, should be applied just before rain.

Liquid manure.—Manure of almost any description is quicker in its action if used in a liquid state. It has the advantage that it can be employed at any season of the year, whenever nourishment is required. Liquid collected from a heap of farmyard manure exposed to rain is the most valuable, as it contains the most fertilising properties. Cow dung is easily obtained, and forms one of the best, and is the least dangerous. The excrement from sheep, deer, fowls, and pigeons is of a more powerful nature, and should be used in a weaker state.

On turf, especially inland, a dressing of salt produces good results. The benefit of salt is generally seen on lands near the sea shore, and for some distance inland, where they receive the deposits from the salt spray carried inland, by storms. Its great affinity for water has the effect of attracting dews and atmospheric vapours to the growing vegetation. Salt is also useful both for destroying slugs, worms, etc., and as a preventive of insects laying their eggs in the grass.

The difference between Organic Manures and Inorganic Manures is this: Organic manure contains the three elements of plant life in strength according to the quality of the manure. Inorganic or chemical manure contains only one, and may be used as a stimulant only, although a stimulant must not be substituted for a plant food.

The contrast between a stimulant and a complete fertiliser, is the same as a man working hard. If he is fed well, he can go on working for an indefinite period, but if he is only given a stimulant occasionally, he soon tires.

When the heat in the soil falls below a certain temperature, the bacteria in the soil remains dormant; hence the necessity of the different methods of manuring being used in the Autumn and Spring. In the Autumn only dressings of a slow-action manure should be used to keep the soil in a healthy condition during the dormant season. If soil is in a healthy condition, as soon as the warmer days of Spring come a light stimulant may be given with advantage to assist and quicken the bacteria into activity, and prepare it for a dressing of a complete fertiliser.

Manufactured or artificial manures are mixed for the purpose, and should always be bought from a reliable firm who make a speciality of this work.

The two best reasons for buying manures for grass from reliable firms are: First they are always experimenting, and are always open to try anything new; they also have the laboratory at their disposal, and are willing to place the best of their knowledge for the benefit of the public. Secondly, they have special machinery for grinding, screening, and mixing finer manures, so that they can be distributed more evenly over the surface of the Green.

Greenkeepers, too, are constantly trying new experiments, and it is by this method that experience is gained, but it is advisable to keep a patch of turf for this purpose.

In mixing manures, although the land is equally as much in need of phosphates and potash, they must be equally balanced with nitrogen, because if any of the three elements are missing, no excess of the other two can make up the deficiency, and in using a badly blended manure the composition of the herbage of any Golf Green might be entirely changed.

In using compost, no more should be used at any one dressing than what will entirely disappear with light brushings, or, for preference, passing a light board over the surface. Heavy dressings should never be given, because they choke up the air cells. In Spring, light dressings can be given to advantage about every three weeks.

No hard and fast rule can be given for specified quantities of any manure to be used, as the soil, climatic conditions, the season of the year, and the state of the turf, are the leading factors. As much damage can be done to the turf of a Golf Green by overfeeding, as well as by underfeeding. Always err on the right side; a little and often during the growing season is the safest rule.

Essay Competition for 1926.

By GEORGE ALLCORN, H.H.G.C.,
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CONSTRUCTION OF PUTTING GREENS.

WHEN it has been practically decided that a Putting Green shall be constructed at a certain spot, it is then that vital questions arise. These questions require very careful thought. There is the size, shape, the fitting in with the natural surroundings. Whether it is to be grown from seed, turfed, or whether the existing turf be fed to get the required consistency for a good putting surface. Before actually commencing any work, it is necessary to have an absolutely final programme. If it is to be the "home" Green—the ninth would come under this heading if the Course is arranged in two loops of nine holes—these are usually larger than the other sixteen, being anything from 600 to 1,000 square yards. The remainder are round about 400 to 700 square yards.

Now the shape. What I mean by shape is, should they be oblong, square, round, or look " natural "? I personally think "straight line" greens, and perfectly oval or perfectly round, look much too artificial. This is made much more apparent where Greens have to be fenced in, as one finds on many inland courses. On some I have in mind every Green is fenced off in a square, and the Green is cut as close to the sides as the machine will admit, thus making the artificial appearance predominate. This could be altered by having part of the approach and the sides fenced with irregularity.

Where no fencing is necessary, and you are free to Bunker as much as is thought necessary, the shapes and banks of the Bunkers and Mounds, which should be moulded the same time as the Green, should give you the natural irregularity required. Where the existing ground is already naturally irregular it should not be interfered with unless absolutely necessary.

The best Golf Architects are all the time endeavouring to imitate nature and natural surroundings. Some have attained considerable success in so doing.

It is necessary to know the nature of the soil for your Green, or the "chemical affinity" of its contents before you can decide what treatment, if any, it will require. Any deficiencies of grass food constituents should be replaced in the soil before thinking

about seeding or turfing. The aim should be to obtain and keep a perfectly firm surface.

In constructing a Green on sandy soil, whether it is to be sown or turfed, it is necessary to preserve every bit of subsoil. This should be removed, and placed in close proximity, whilst shaping the intended ground for the Green.

I advocate the following procedure in preparing a seed bed for a Green on pure sand, such as is found in the ironstone area of Lincolnshire, where my course is situated.

Preserve what subsoil there is, then dig out to a depth of from two to three feet of sand, cart this away to help in forming Bunkers and Mounds or for whatever purpose necessary. This two or three feet must be replaced with loamy soil mixed with peat moss. On top of this, the subsoil mixed with loam and well-rotted horse straw manure. At this period, after being well hand-rolled, the surface should be at least six inches higher than its intended level, i.e., you took out three feet, say, and replaced it with three feet six inches. Owing to the loose nature of its contents it will settle down the six inches in a comparatively short time. As long a time as possible should elapse before sowing, and seed should be used of the kind adaptable to the soil imported. Sow at the rate of from five to six ounces per square yard.

The peat moss retains moisture and helps it to withstand a dry summer or drought. It is of especial value where no water is laid to Greens.

Remembering that each square yard of soil contains considerable quantities of weed seeds, it is important to allow these time to germinate, and be removed, before sowing any seed. When a Green is to be turfed, all weeds that can be seen in the turf should be removed before it is laid.

In constructing a Green on clayey or heavy soil, the first consideration should be drainage. On a Golf Course it is not necessary to make deep drains, as farmers do, as they drain below the reach of the plough and other implements. A few shallow drains composed of clinker, cinders or coke breeze, about six inches below the surface, providing the water stratum is tapped, is sufficient generally. It may be found necessary to drain the approach, or to any one side of the Green. This must be decided on, and done in the initial stages of construction. Just after or even during heavy rains or gales is the time to walk round the Course, and see just where the water lies, using judgment in deciding whether a drain here or there would do any good. In many cases a shallow drain put in from forty to a hundred yards away and even off the line of play would keep a playing

part of the Course dry. It is only by reasonable observation during heavy rains that this can be seen.

One can see by the excavations what class of soil is present, and can prepare the necessary ingredients to make it adaptable for the fine grasses necessary for a putting surface. These should be added at the proper time and put in the proper place, i.e., where the grass roots can reach it and live on it. Care should be taken that at least three parts of the Green lends itself to be available for the hole, because frequent changing is necessary if the Green is to be kept in condition.

CONSTRUCTION OF BUNKERS.

A FEW of the main things to keep in view when constructing Bunkers are the following: Length of hole, position, size, shape, use, prevailing winds, uphill, downhill, and the "run" of the turf.

Every Bunker should be of value. The fewer the better, so long as they are of real value. They should be made to look as if they were part of the natural features. Also, be economical in upkeep. Eliminate scythework as much as possible. Make the banks so that a machine will take them. Turf should run well in to the bottom from the fairway, so that there is not an abrupt drop from the fairway into a Bunker, but a gradual slope.

The "bay" style of Bunker is the most satisfactory, whether on clay soil, where sand has to be imported, or where the only "soil" is sand itself. The "wing" portion of the "bay" helps to keep the sand in the Bunker, and affords protection against winds from any quarter.

In very large Bunkers the wings should be turfed right into the bottom, tapering off fairly narrow, say from one foot to two or three feet. Despite notices placed under the very noses of the players, "not to walk through the Bunkers," as soon as they have extricated their ball they almost invariably go " over the top." These turfed "wings" would afford a path to walk on, thereby preserving the walls of the Bunker.

I have constructed this pattern of Bunker on my present course, and am gradually converting those that give me trouble by banks being torn down by players. I have studied the ways of players in walking in and getting out of a Bunker, and have endeavoured to give them a " line of least resistance " in getting out—the main object being, of course, less trouble to the greenkeeping staff, as well as the members themselves.

Sand is, of course, desirable in Bunkers. Where this is at a premium, Bunkers, so called, become atrocities. Shingle, beach stones, and gravel should never form the sand, or part of the sand in Bunkers round the Green, because, when players

explode their shots, intentional or otherwise, some of these small stones will fly on to the Green, even if the ball does not. The larger ones can, of course, be easily removed, but it is the smaller ones that cause trouble to the knives of the mower, and putts to be missed. Where sand has to be imported it is an expensive item, and the cheapest product is usually purchased, but it is really worth while to pass it through a screen before putting it in Bunkers, for the above reasons.

No Bunker should be so constructed that any part of it is impossible to play out of. They should be visible, in parts at least, from whatever position a shot is to be played from, and so built that a ball should roll towards the centre.

Bunkers round the Green should be deeper and narrower than those through the Green. The latter should be wide and shallow.

The soil removed in making a Bunker should be utilised in its bank, which should gradually taper into the natural features of the surrounding ground. Well-constructed, well-kept Bunkers are pleasing to the eye, and although "inanimate objects," really do have a great effect on all classes of play and players.

The Bunkers on most inland Courses always carry a trimmed appearance in comparison with natural sand-blown Bunkers. In most cases this is unavoidable, although very wealthy clubs can import sufficient sand and grasses to imitate sea-side links.

CONSTRUCTION OF TEES.

SOME of the main points to work for, in the construction of Tees, are the following: Attractiveness, a roomy feeling, a beautiful level floor of nice green turf for the background of the white ball, to give a nice feeling of comfort when the stance is taken; to give a conscious sense to the player that the Tee is helping him to fit himself to the line of play. It is desirable that we make Tees that will exude the above qualities.

Regarding attractiveness, it used to be thought that this quality was not really necessary in a Tee; that players would go to the Tee-ing ground whether it was attractive or not. We know what effect surroundings or environment has on ourselves, when visiting other courses. We know, too, when we go on to a short-hole Tee, that it is really unnecessary for such large Divot-holes to be there. I should like to see in addition to length of hole and bogey on the Tee-box, these words, " Use a bit of sand." I'm certain the majority of players would get better results by so doing.

Some seem to be imbued with the idea that they must take turf with their irons. The wee bit of turf taken "in front" of

the ball after a correctly hit iron-shot does not worry the greenkeeper so much. It's when huge cavities are left, and one see the dried up divots " dead and dying," in front of a short hole Tee, that one thinks, is it necessary? Recent years have shown marked improvement in the size of Tees. It is now generally admitted that a Tee should not, unless exceptional circumstances warrant it, be above the ordinary level of the ground. What I mean is, you may have to build up a side, front or back to get a level and to get size of from 200 to 250 square yards. The little square Tees one occasionally sees on some courses of about 20 to 24 square yards, thrown into the air three or four feet, do not tend to attractiveness, are not economical in upkeep, nor are they conducive to good Tee-shots. In these days of motor mowers it is possible and desirable to have very large Tee-ing grounds. Two Tees of from 200 to 250 square yards, either oblong or square in shape, are more economical in upkeep than three or four small ones.

A coarser and hard-wearing variety of grass is necessary for the Tees, as compared with Greens, as they get much harder wear. Reliable seed firms supply a special mixture of grass seeds for Tees. Every hole should have two Tees besides the medal Tee. As well as giving variety in placing the Tee-shot it affords the ones not in use to be cared for and renovated. The same care in construction, and treatment after, should be afforded the Tees as for the Greens. On wet courses it is a good plan to have a fibre Tee-mat for winter play. An economical one can be made with six ordinary door-mats, screwed into a wooden frame, let into the ground level, and well dressed with sand. A few holes bored in the bottom boards will allow water to get away. They make excellent practice Tees for correcting the stance, as a slight groove is left where one mat joins another.

THE IMPORTANCE OF FEEDING TURF, Etc.

THE importance of feeding turf that is used for Golf is now being scientifically studied by nearly everyone with any responsibility in turf culture and upkeep.

Everything that has life must have the means of existence or it ceases to be.

It is necessary to mention that worms must be kept down in the vicinity of the Putting Green as well as the Green itself. The fallacy that they are necessary in the soil of such is, or ought to be, utterly exploded. Much food value is lost to grass by such pests by their casting up of embryo weed seeds, which feed on food that should be sustaining the grass.

The ingredients composing grass food must be carefully considered and blended in conjunction with the particular soil it is to enrich. There is an old saying that " what is one man's

meat is another man's poison." That is very true indeed when we are considering the feeding of the fine grasses of a Putting Green. We must know that class of soil existing under the grasses. It must be treated, and its contents analysed to find out what it wants. Although we may have constructed this same Green some years ago, and remember what soil we put in, we must not lose sight of the fact that we cannot continually be "taking out," in the shape of wear and cutting, without "putting in." Superphosphate of lime, sulphate of ammonia, and sulphate of potash supply most of the feeding material for Golf grasses.

Sulphate of ammonia is a valuable constituent, but very great care must be exercised in its use, especially on sandy soils. Too much, or too frequent dressings, will eventually cause acidity and sometimes sterility. This is invariably the case where the soil has already a tendency to acidity.

The application of carbonate of lime—light dressings in the rainy season—will do much to eliminate the acid, and make the soil sweet and able to absorb and hold whatever food is put on. The usual and most practical way of feeding the turf is by top dressings of compost, on the "little and often" principle, finely sifted and worked into the turf with a switch, brush, or drag-mats. Although it is put on the top, it is the roots in the soil itself which require this food. The foliage gets its appearance from what food the roots assimilate. A most excellent implement in assisting to get full value from top dressings is the "Sarel Patent Spiked Roller." Besides being used for ventilating the Greens it should be run over them just previous to dressing, and, after the dressing has been worked into the grass, rolled with the "Spiked Roller" again.

I advocate this because of the advent of the motor-mowers and their probable effect on the Greens, *re* making them "hide-bound." The Spiked Roller will balance up this probable effect if used discriminately.

I only know my own Greens get "hide bound," and the only cause I put it down to is the weight of the motor mower. I do not remember having this state when hand mowers only were used.

I know that last year my top dressings lost at least two-thirds of their value through lying in the grass and not being able to penetrate this "hide-bound" surface.

A very valuable food is the grass cuttings. These should be left on the Greens when mowing. To get the value out of it, the switch should be used after mowing.

The switch is a bamboo cane, tapering off very thin, and is about eighteen to twenty feet in length. In about ten minutes an ordinary Green can be switched. Always switch with the

wind at your back. This has the effect of the longer and coarser grass being blown forward, and the shorter grass being buried in the Green to form humus. The switch stands the grass up and enables it to grow its natural way, that is, straight up.

Apart from being switched after cutting, Greens should be switched every morning. It is of great importance to grass life when heavy dews are about.

With equal importance, Tees and Approaches should be switched after cutting, thus providing a food that is vitally necessary in the form of humus.

The compost dressings should be supplemented by complete grass fertilisers suitable to the soil. To make sure of getting suitable fertilisers and grass foods, it is advisable to send a sample of turf to your dealer. It is much more economical and satisfactory.

When using these grass foods, follow the directions, which are sent with them, very carefully, and the result will amply repay you.

Fertilisers of any description should always be used with care, combined with knowledge of the particular soil and its existing chemical contents. Different soils require different treatment. What suits one Green on a Course, may not suit another on the same Course. Therefore no hard and fast rule can be laid down in manuring or fertilising Golf Courses.

The great things in Greenkeeping are observation and experiment. It is unwise to do experimenting on Greens or any part of the Course that is in play, for obvious reasons. I maintain that a turf nursery should be distinct from an experimental station, although they should be in close proximity. It is on these that seeds and fertilisers should be tested. The turf nursery should receive the same attention as the Greens, no more and no less.

As Greenkeepers we can only do the best we can with the material available. This " material," apart from natural resources, is the financial situation of the club. Experiments cost money in every sphere of action.

Therefore, it is cheaper in the long run to get advice about your Course from the leading seed establishments who supply scientifically blended complete grass foods, to suit all soils. Seed merchants are also ready and willing to give expert advice on any subject connected with the upkeep of Golf Courses. Progressive clubs take advantage of this.

One must be able to differentiate between fertilisers that can be used as food, as distinct from stimulants only. The latter should seldom be required. Nature is a very exacting mistress, you never know when you have got her. As I read a short time

ago, " Beware of the man who says he understands Nature, he is more dangerous than the woman who says her husband does not understand her."

" By ignorance we mistake, and by mistakes we learn," is particularly applicable to Golf and Golf matters.

There are roughly three classes of manures—

1. Organic or natural manures.
2. Artificial or manufactured manures, and
3. Special manures made to encourage certain crops.

The first two are of the most importance to us, the third being more for agricultural purposes.

Organic or natural manures are of more value on light sandy soils, and incidentally, artificials usually give better results on heavy soils. However, both are needed in proportion for each class of soil. Golf Courses must be fed. It is of great importance that discretion is used in the application of artificial fertilisers, and the safest plan is to get expert advice about the local conditions and what artificials are most likely to prove beneficial.

In some cases this advice is sought after considerable damage has been done, which is irritating and expensive.

Fertilisers containing nitrogen, phosphoric acid, lime, and potash are necessary for Golf Greens, these being the constituents that are used up quickly, owing to cutting. The best time for dressing with organic manure in the form of compost is the spring and autumn (say, between the 16th and 28th of March, and between the 22nd and 28th of September), when winter grass is changing into spring grass, and summer grass begins to assume its wintry condition. This is very important, as the dressings help to protect the grass roots from the summer sun and winter frosts and cold winds.

Supplement with two light dressings of Sutton's Complete Grass Food, one about mid-April and the other in the middle of May, selecting suitable weather conditions.

The Greens should look and play well all the year round. These dressings should be persevered with, year after year. If lime is required, give two light dressings, two ounces to the square yard, about the middle of October and the middle of February, at two-year intervals. Give dressings time to get firmly established in the soil before putting on another. Watch for results and make notes of anything occurring out of the ordinary for future guidance and reference.

Much damage is, and can be caused, through being too haphazard in the application of dressings. Make sure that each dressing is evenly distributed. Every Green should look all

over alike. It depends on how it has been fed and dressed, whether this result is obtained or not. It is very galling to see bare patches on Greens in June, when, other things being equal, they should be covered with a beautiful carpet of fine grass, and if the cause of it is indiscriminate manuring, it should, and undoubtedly does, make the Greenkeeper " sit up and take notice " for the future.

I have found the following useful as weed-killer—

3lb. sulphate of ammonia.

1lb. sulphate of iron.

Mixed with 20lb. of sand.

Spread a little over the Green on a dry day. Mixed in large quantities it can be used at the same time as a fertiliser.

For fetching a Green up quickly:

6lb. sulphate of ammonia.

2lb. sulphate of iron.

40lb. sand.

Use 28lb. per Green of 400 square yards.

The latter gives excellent results if used at the proper time, i.e., when Greens show signs of being " run down," and the grass takes on a slightly yellow hue. It should not take the place of a grass-food dressing.

It is to the advantage of every Greenkeeper to read and digest mentally, every possible book and article on Greenkeeping, and utilise this "theory" (shall I call it?) and deduct from it by observation of their particular soil and vegetation—to sift the "oats" from the "chaff" as applicable to their own Course. Most of the books and articles can be relied on, as they are usually written by experts, after scientific experiments and investigations, in every sphere where golf is played.

George Eliot, in one of her books, says something like the following, " If a man can make two blades of grass grow, where only one grew before, he is an asset to the God of Nature and his country."

GEORGE ALLCORN, H.H.G.C., Scunthorpe, Lincs.

Essay Competition for 1926.

By SYDNEY SELLARS,
Thanet Golf Club, Margate.

CONSTRUCTION OF PUTTING GREENS.

IT has been asserted, and the contention is, without a doubt, correct, that the first requirement in the formation of a Golf Course are well-constructed Putting Greens. Any reasonable expenditure incurred in adopting the best methods of soil cultivation, etc., will bring its own successful return.

While it is comparatively easy to dig over the sites, rake, roll, and sow seed, or lay turf, it is not always economical, and is very often a matter of burying troubles, which rise again in a much more aggravated form.

It is best to start the work so as to have the Greens ready for seeding in the early Autumn. The soil and climatic conditions at this time of the year are, as a rule, in the best state to assist germination. Moreover, Autumn-sown grass has a decided advantage over the weeds of the following Spring. Turf also has a better chance of establishing its roots if laid during the coolness of the Autumn. There is always a susceptibility for Spring-laid turf to shrivel through drought.

Whenever possible, I am a believer in plasticine models to work from; they give the men employed an idea of their completed job.

In commencing the construction of a Putting Green, the site should be cleared of any existing turf. After this has been done, the general outline of the Green is made.

Without unduly trespassing on what may be described as part of the architect's work, the following points are given:—

Symmetry must be avoided; things made to match do not suit the surroundings of a Golf Course. It is always better to avoid angles, and use curves. Hummocks shaped like tents and banks, or like housetops, are unsightly, and provide impossible stances.

No Green should have corners; the shape should be kept curved.

When undulations on the putting service are desired, these should be few, especially on small Greens, and made with gentle slopes in such a way that when a ball is hit it remains under the influence of the stroke; also, a mowing machine should pass over the top of any undulation, without causing injury to the turf.

Careful attention should be paid to the effect these features will have on shots "through," as well as on the Greens. The finishing touches are, of course, put when the surface is being finally prepared. The methods adopted in making a dead level Green, by means of a spirit level, pegs, straight edge, or boning-rods, are too well known to warrant going into details. A most important matter, however, whether constructing either undulating or level Greens, is to keep all the good soil to the top, no matter how much wheeling it may entail.

Newly-broken grasslands, that have had no cultivation for perhaps a number of years, are nearly always infested with hosts of pests, such as wireworms leatherjackets, cockchafers, etc., and where Greens are being constructed on ground of this description it is worth while to ascertain to what extent these pests exist. Financial circumstances seldom permit of the sites being broken in the winter, fallowed the following summer, and seeded in the Autumn. This is a counsel of perfection, but where perhaps only one or two Greens are required on an established course, it may be practicable. and, if so, will do a great deal towards ridding the land both of pests and rubbish.

No success can be expected from any attempt to produce a good Green on a waterlogged soil; it becomes overrun with moss and other weeds, a muddy, tender surface ensues, which in dry weather sets harsh, and excludes all air from the roots of the grasses, besides being totally unsuitable for the pitch of a golf ball. It is necessary to adopt an efficient system of pipe drainage, when such conditions prevail. While this is a subject in itself, here are some of the principal details connected with it:—

The herring-bone method is one that recommends itself as being the most suitable for Putting Greens.

To be well made, a drain pipe should give a clear, ringing sound when tapped.

The main pipes are four inches in diameter, and the branches three inches. In laying, the mains are placed in trenches of suitable depth, with an even fall of approximately one foot in one hundred feet, following the natural slope of the ground, and ending in a well or some spot where the surplus water can do no damage.

The branches are laid so as to join the mains at an angle of about 45 degrees, sloping approximately one foot in seventy-five feet. Trenches will need partly filling with breeze or rubble to ensure water reaching the pipes.

A good way to drain small hollows where only the surface soil is waterlogged is to bore a series of holes with an ordinary hole-cutter, as deep as possible, and fill up with porous material to within about six inches from the top. This is only satisfactory when the water can get away in the subsoil.

The work of preparing the soil is a very important item in the construction programme, the object being to acquire a clean, friable soil, sufficiently rich in humus to promote a healthy growth, together with a degree of porousness whereby sufficient moisture is conserved and the surface remains firm without becoming crusty or harsh.

The following suggestions on the manner of treating various soils may be applicable, but modification will be required to suit the climatic and geological conditions peculiar to certain districts; also the purse of the club concerned.

On heavy soils where clay predominates a system of double digging should be adopted. This means keeping the surface soil to the top and thoroughly breaking and improving the subsoil.

A trench two feet wide is dug out, the top spit and crumbs being removed to opposite end of site, ready for the last trench. The subsoil is then broken, and breeze or other porous material added in order to assist drainage. The surface soil from the next trench is placed on this prepared subsoil. If lime is deficient in it (which can be ascertained by placing a small quantity of the soil in a jar containing a little diluted hydrochloric acid, if there is no effervescence, then lime is required), it should be applied in the form of carbonate of lime, at about 1lb. per square yard. This, together with well-rotted stable manure and fine breeze, will provide an open surface in which sun and air can penetrate, and, while conserving a certain amount of moisture, will allow percolation to take place. The same procedure is adopted until the last trench is reached. Care must be taken to tread each trench well, and all prominent weed roots will be picked out as the work proceeds. It may be necessary to remove some of the subsoil to make room for the added materials.

After the digging is completed and the soil settled, the Green should be top-dressed with a layer of finely sifted compost 2 or 3 inches thick, the surface rolled and raked until perfectly firm and true, when seeding or turfing can be commenced.

Where Greens are of a raised type, the materials can be added as building up is carried out. In either case, when adding materials, ensure uniform distribution; it is no use putting manure 4 inches thick in one place, and 1 inch in another; also, it must not be forked in so deep that the roots of the grasses haven't a chance of reaching it.

On light, sandy and gravel soils, the same method is adopted, leaving out the porous making material, and adding instead a good loam, also substituting pig manure for stable manure. This binds the soil together, and conserves moisture better. When stones abound, these should be sifted out to such a depth that they won't come into contact with the hole-cutter.

Where Greens are being constructed on heather lands, particular

attention should be paid to drainage and liming. The subsoil will require the porous materials, especially if peat is plentiful. Horse manure is good for this kind of land.

On thin soils overlying chalk it is necessary to provide an increased depth, either by adding to the existing surface or excavating a foot or more of the chalk. Horse manure is suitable, and while no pipe drains are required, breeze should be added, as this class of soil is usually very tenacious. It is as well to test for lime, for although overlying chalk, there is sometimes a deficiency at the top.

Next comes the question—Turf or seeds? Personally, I prefer the latter. I am aware that good grass seeds are expensive, bad grass seeds are more so, but bad turf costs a fortune. If it has been nursed and weeded for a year or so previous, turf may be passable, but it is generally taken from some field or marsh and laid direct. It usually contains all sorts of weeds and unsuitable grasses, to say nothing of insect pests and their eggs. However, if it has to be used, the best way is to lift 1 foot by 14 inches, and to pare it off through a box to a thickness of 1½ inches.

After the laying process, the turf should only be rolled sufficiently to ensure solidity; two or three times with a moderately heavy roller are ample; continuous rolling before knitting takes place presses the surface soil down so hard that the young roots have difficulty in establishing themselves. I don't advocate cutting of any kind until they are thoroughly established.

On a Putting Green a heavy beater should never be used; if the turf has been properly cut, and the surface made firm and true, a small mallet to gently tap each one down to the soil will be sufficient. Anything heavier merely smashes the turf and serves no useful purpose.

In deciding on grass seeds, it is advisable to study the surrounding grasslands, and note the indigenous species which are suitable for Putting Greens. Go to a first-class seed firm, mention these species and the type of soil, and leave the rest to them. There are firms who make this work a specialty, and can compound mixtures to suit any soil. A look round the laboratories, testing apparatus, and trial plots, assures one of the infinite care that is taken in removing impurities and producing mixtures only of the highest quality and suitability.

Seeds should be sown on a calm day. As stated, the surface must be quite firm and have a fine tilth. Even distribution is essential, to facilitate this. Line the Green off in strips, 3ft. wide, making two sowings, viz., lengthways and across, using 1oz. of seed per square yard, at each sowing. In the same way cover the seeds, raking and rolling first across, and then down the site. To secure

good germination, care must be taken not to bury the seeds too deep or leave them exposed. A thin covering is all that is required.

CONSTRUCTION OF BUNKERS.

A good Bunker may be described as one that retains the badly-played ball which it was designed to catch, leaving it in such a position that the player has a reasonable chance of recovery. It should suit the position it occupies, insomuch that it has a natural, not artificial appearance. To this end much depends on the imagination of the constructor and his knowledge of golf.

Flat courses, where one gets a little help from Nature, are the most difficult to bunker. When banks and hummocks have to be made, their slopes should be varied in height and shape, and tapered to the ground level, to enable players to get a reasonable stance.

On light sand courses where it may be desired to make the face with a turf wall, the turves, usually about 3ft. long, are laid in a similar fashion to bricks. They should be started in a trench 15 inches deep, in order to provide a foundation.

Acute angles and deep bunkers do not combine, and the slope of the face should be made in ratio to the depth, so that a well-played niblick shot will get out. It should not be so easy that one is able to get almost the same distance as if on the fairway.

Bunker bottoms should be either grass or sand. Where circumstances don't permit of sand being used, it is better to resort solely to grass rather than try to make a kind of earth bottom, which becomes a source of trouble through weeds, and is always either muddy or harsh.

The surface should be concaved; this helps to prevent sand from blowing out, and also has a tendency to make a ball roll away from the face, towards the centre of the bunker.

Irregularity in bunker construction tends to hide artificiality A group of bunkers interspersed with clumps of whins, broom, etc., give that natural appearance which is very difficult to describe on paper, yet does so much towards making a course more interesting and pleasant to play over.

CONSTRUCTION OF TEES.

Good drainage is the first consideration in the construction of teeing grounds, and raised Tees help in this direction on wet soils.

The site is first cleared of turf, which should be retained if fit for use. A foot or more of soil is excavated, and a good foundation of cinders or rubble, well rammed, made in its place. The Tee is then built to the desired height, incorporating with the soil the same materials as for Putting Greens. The surface is either made level

or slightly sloped backward (never forward), and should be top-dressed with compost consisting of two parts sand, and one part soil. Care must be taken to ensure a long enough slope to the sides of the Tee, in order that these can be easily cut with a machine. They are best rounded at the top so that the turf will not be injured. A less uniform appearance is given if the slopes vary in length and are kept slightly convexed. The ground should be thoroughly settled before the turf is laid. If good fibrous turf is not procurable, a mixture of seeds specially prepared for teeing grounds should be used.

FEEDING OF TURF.

Soil is made up of organic and inorganic matter. The former, known as humus, has been provided by the decay of animal and vegetable substances; the latter, in the shape of sand, clay, and limestone, originated from the effects of climate on rocks. Taken separately, the value of these components of soil to plant life, may be described as follows:—

Sand lightens the texture and allows moisture and air to penetrate.

Clay conserves moisture, and has the property of holding manures..

Limestone prevents acidity, and decomposes organic matter.

Humus improves the physical character, conserves moisture, and supplies plant foods.

In so far as fertilisers are used as a means of supplying plant foods, it can be stated that of all the materials used by plants from the soil it is only necessary to return three, viz., nitrogen, phosphates, and potash. These are the only ingredients that count in judging the value of any fertiliser (lime is excluded here, as its value lies chiefly in the action it has on the soil rather than as a plant food). No matter how well the soil on which turf grows may have been prepared during construction work, the food supply will continue to need replenishing. Its depletion, in addition to normal growth, may be attributable to continuous cutting, climatic excesses, wear, and pest ravages.

When a box is not used, a certain amount of humus in the form of decayed cuttings is returned; this, however, is a disadvantage by the fact that at certain times of the year weed seeds are distributed. In any case, it does not make good the total loss sustained. Generally speaking, no turf consists entirely of grass; numerous other plants indigenous to the soil on which they grow are each making their own struggle for existence, and a great factor in successful

feeding is to balance the foods so that they give the desirable grasses a distinct lead over other forms of plant growth.

Grass has no means of enriching itself, and providing there is no acidity in the soil it readily responds to a nitrogenous dressing. Clover, on the other hand, is able to draw nitrogen from the air, and if supplied with phosphates and potash soon assumes a lead in growth. It is obvious, then, that unless a Green is sufficiently rich in nitrogen to supply the wants of grasses, phosphatic and potassic fertilisers should not be applied. It is advisable to keep a record of all manurial treatment, together with notes showing extremes of temperature and rainfall. In this way, one is able more readily to understand the peculiarities of certain soils, and the changes which take place in the botanical character of the turf through the application of fertilisers, worm-killers, etc.

The following are suitable fertilisers for turf, but, as already inferred, so much depends on the character of the herbage that it would be unwise to vouchsafe these suitable under all circumstances.

Nitrate of soda, a nitrogenous manure highly soluble, very rapid in action, sinks quickly to encourage deep-rooted grass; is not suitable for Putting Greens, but is valuable for Fairways on heavy soils as a spring dressing and stimulant. Suitable rate of application 1 cwt. per acre.

Sulphate of ammonia is very useful and a very stimulating nitrogenous fertiliser; can be used on Putting Greens on all soils except where lime is deficient, its stimulating effect is particularly beneficial in the early Spring or after greens have had a hard Summer's wear. It is largely employed in the composition of lawn sands, its caustic action killing daisies and other broad-leafed plants; ½oz. per square yard is a suitable dressing. This fertiliser has a tendency to promote rather a rank growth, and to prevent this should be mixed with two or three times its own bulk of sand. Also, if used too frequently it is liable to cause acidity.

Rape meal and soot are other nitrogenous fertilisers; the former is particularly suitable for young grass and newly sown Greens on all soils. Rate of dressing, 3oz. per square yard. The latter is also valuable, but is unsightly and is a nuisance to players.

Bone meal and dissolved bones, although classed as nitrogenous phosphatic manures, contain only a small percentage of nitrogen. They are slow in action and encourage clover in preference to grass; cannot be recommended for Greens, unless used in conjunction with sulphate of ammonia.

Peruvian guano, another very useful grass food, contains all three ingredients and is very good for greens on light soils, also

to young grass as an initial dressing; should be applied in the Spring about 2oz. per square yard.

Of the purely phosphatic manures, basic slag and superphosphate are the most important. The former owes its value to the amount of phosphate of lime it contains. The finer it is ground, the better. Broadcast in the autumn at about 5 to 8 cwt., per acre, it is beneficial to Fairways on heavy non-calcareous soils; better results are obtained if it is supplemented with a spring dressing of sulphate of ammonia. As it promotes very free growth of leguminous plants, it is unsuitable for Putting Greens. Superphosphate contains usually about 30 per cent. of soluble phosphates; applied at the rate of 2oz. per square yard it is more suitable than slag for calcareous soils; it has a destructive effect on moss and pearlwort, and used in conjunction with sulphate of ammonia will encourage grasses in preference to daisies, buttercups, and plaintains.

The principal potash manures are kainit, sulphate of potash, and muriate of potash. Potash can be considered for turf only when employed in conjunction with nitrogen and phosphates. Sulphate of potash, apart from its manurial value, is useful in destroying the eelworm pest. The quantity to apply is 1oz. per square yard.

On Greens that have been thoroughly spike rolled a good compost, finely sieved, formed of well-rotted stable manure and soil and well brushed in, improves the physical character, besides supplying a certain amount of the three plant foods. Malt culms and peat moss have much the same effect. The difficulty with composts is that in all soils weed seeds exist, though they may not germinate until they come under the right conditions of temperature, etc. Any kind of farmyard manure used for making composts should come from stock that has been well fed; certain foodstuffs, especially oil cakes, are rich in nitrogen. Also, a greater quantity of nitrogen is found in the urine of animals rather than in the solid excreta. Consequently dung which contains a large amount of urine (absorbed in the litter) is the most valuable.

There are advertised a considerable quantity of proprietary manures at the present time. Some are advertised as being particularly suited to Golf Course requirements. Purchasers should make a point of ascertaining and understanding the amount of nitrogen, phosphates, and potash they contain, and how quick they are in action. If purchased from a reliable firm, who are Golf Course experts as well and understand the requirements of each individual, a complete fertiliser may be relied upon as being one of the safest and best forms of feeding turf. The presence of lime in soil is necessary for the growth of grass. The decay of organic matter is incomplete when it is absent. It sweetens soils, and is useful in

reducing Yorkshire fog and bent grasses. A method of testing for lime has already been stated under "Construction of Putting Greens." An excess of lime encourages clovers. Carbonate of lime and gypsum supply the wants of turf; the former should be applied in the form of fine powder during winter at about 1 lb. per square yard; the latter is especially good for mixing with compost.

Fresh air is essential to the well-being of turf, and the value of mechanical treatment, such as spike rolling, harrowing etc., cannot be overestimated.

In the application of fertilisers, the maxim " little and often " is a good one. They should be in a fine powdery condition and distributed on a calm day.

It is well to remember when feeding Putting Greens or any other form of turf that what is a food when used with discretion may prove to be a poison if indiscriminately used. While nitrogen chiefly aids grasses, and potash and phosphates encourage clover. the continuous use of nitrogenous manures alone will eventually result in deterioration.

Milk and eggs may be fine foods for feeding human beings, but if we lived on them exclusively we should eventually be surfeited and perhaps appreciate a glass of beer.

The same argument applies to turf.

SYDNEY SELLARS,

Thanet Golf Club, Margate.

Some Important Subjects in Greenkeeping.

By GEORGE A. KINNEAR.

GOLF architecture and greenkeeping has never reached such a high state of efficiency in our country as at the present time. The popularity of the game has played an important part in the scientific progress of the construction and care of the Greens. On many parts of the sea coast natural golfing country is to be found, but most of that has been laid out to advantage years ago; now, inland golf is just as fascinating.

No attempt should be made to standardise Golf Courses, since each Course has natural features and these should be well studied by the Greenkeeper before starting any construction work. The beauty of the landscape must be considered, and the Greenkeeper must adapt his scheme to this, without attempting to reproduce any hole similar to those already in existence.

CONSTRUCTION OF PUTTING GREENS.

Local conditions have a great deal to do with the construction of a new Green. The differences of subsoil, aspect, position and drainage should all receive attention. To simplify orders to the staff it will be a great advantage to make a model of the Green in plasticine or clay. If the site be on good loamy soil, remove the top spit or surface soil and place aside; put in the desired system of drainage, work out the design with the subsoil, and replace surface soil. Should the Green be too light and poor, or too heavy, an effort should be made to procure sufficient loamy soil to cover the surface of the Green to a depth of at least three inches. Although not always practicable, it is an advantage to allow as much time as possible between this preparation and the turfing or seeding, that the ground may consolidate and for the destruction of the weeds.

Turf should only be used under specially favourable circumstances.

For the preparation of the seed-bed, well-rotted stable manure ought to be spread over the surface at the rate of one load per hundred square yards, and forked or dug into the soil in such a way that the bulk of it remains within two or three inches of the surface. Artificial manures manufactured by some of our leading seedsmen are sometimes more convenient to use. Sow it evenly over the surface at the rate of two or three ounces per square yard and lightly rake in a few days before seeding time. Prepare the seed-bed by breaking up the clods, removing large stones and all weed roots with an iron toothed rake; then tread, roll and rake the ground until the surface is quite firm, true, and fine, as the finer the tilth the better the germination of the seed.

The best season for sowing grass seed is the end of August or

during the early part of September. April is generally the most favourable month for spring sowing.

It is important that the prescription of seed be adapted to the soil and for the purpose of which the sward is used. Buy good seed, for of the success of cheap mixtures the less said the better. Choose a calm dry day for the sowing; sow half the seed—either by hand or machine—moving in one direction, then sow the remainder crossing at right angles. This method will ensure an even distribution of the seed. Rake the surface very lightly in two directions, taking care not to bury the seed too deeply, then roll and cross roll with a light roller.

When seedlings are about one inch high they benefit greatly if a dressing of prepared compost be scattered over the ground, thus protecting them from the extremes of temperature and helping to retain any moisture. Rolling with a light wooden roller would do no harm now provided the surface is dry. The grass may be cut when about two inches long with a scythe or a free-running mowing machine, set high, but no work should be done on a new Green if the surface be wet, for the roots of the young plants will surely be loosened and possibly pulled up. The rolling and mowing part of the preparation can now be carried on till the Green comes into play.

CONSTRUCTION OF BUNKERS.

One advantage the seaside Course has is the unlimited range of natural hazards. When the artificial hazard is required, the natural features present on each Course have to be selected for their special purposes, and Bunkers constructed to look as natural as possible. Different positions vary the work of construction. A Bunker should be sufficiently wide and deep to catch and retain bad shots, yet give the player reasonable chance to regain the fairway. The height of the bank and the depth considered with the width, so as to prevent impossible lies, such as would be should the Bunker be too narrow and deep.

For a Bunker on the side of a hill or slope mark out an irregular portion of the ground, allowing extra measurements for the slope of the Bunker face and inward slope.

Should good turf be on the site, cut out turves, three feet by one foot, roll up and put aside, excavate material to the required width and depth and haul away. Returf face and inward slope, introducing patches of heather, rushes, or rough grass. Cover the bottom with sand at least six inches deep.

For a Bunker on level ground, if it be necessary to raise the rampart or mounds above the existing ground, mark out an irregular section of the Course, allowing extra measurements on the side where the mounds are to be, remove the turf, the material excavated from the hollow, throw up in a broken irregular line with the far slope roughly four times as long as the height above the existing ground level. When the mounds have consolidated, returf, introducing

patches of heather or rough tufts of grass for an artistic and natural effect. Then cover the hollow with deep coating of sand.

A slight lip on the ends of the Bunkers in exposed positions will prevent the sand blowing away.

Grassy mounds or hummocks, varying in height and width, make good hazards, especially in districts where sand is scarce or drainage defective.

CONSTRUCTION OF TEES.

The importance of a good starting place cannot be overlooked. All Greenkeepers will find Tees the most difficult part to keep in good condition, as they are subject to much more hard wear per square yard than any other part of the Course. The Teeing ground requires to be well and truly made, and of sufficient size to permit frequent changes of stance. An important point to be observed is that it shall face in the direction of guide-post or green.

The construction varies with the different positions.

On sloping ground, or where there is an abundance of heather and other rough herbage in the foreground, it is necessary to build up Tees.

Through the middle of the proposed site set up three stakes, altering their relative positions till the true direction for the guide-post or centre of the Green is found. Then measure from the stakes outwards to the limits of the Tee, mark out limits with pegs, allowing extra width according to the slope required. If existing turf is useful, strip off and set aside. A shallow trench around the outer mark should then be got ready making it slope slightly inwards. This principle of construction is necessary for the stability of the Tee owing to the friability of the material employed. A layer of thick cut turf should be used all round the trench, laid similar to the foundation bricks of a building, but still following an inward slope, and on the top of this another layer should be placed before the rough soil is spread over the bed of the Tee. This keeps the outside edge higher than the main body.

Follow the same method of construction to the top. Keep each layer of turves nearer the centre than its predecessor, so that when completed the slopes are at an easy angle.

A three or four inch layer of breeze under the top layer of soil will ensure perfect drainage.

When consolidated, rake, tread, and roll, till a firm and level surface is obtained; then sow a suitable prescription of grass seed, or turf with the best-wearing turf that can be obtained on the Course.

On level ground, Tees can be constructed in a very short time. With three stakes find the true direction to guide-post or centre of Green; measure from these stakes outwards to the required width theTee. Strip off turf and put aside; remove top-spit, level off the subsoil, put in three inches of breeze for drainage, replace the top-spit, tread, rake and roll, till the surface is level and fine, sow grass seed or returf.

Several Tees should be made on each hole, thus affording a means of adaption to varying winds.

Patches of heather, and rough tufty grass give a very pleasing effect on the slope of the Tees.

THE IMPORTANCE OF FEEDING TURF.

To keep turf in good condition it is essential that soil must be enriched from time to time with natural or chemical manure. No matter how good the soil may be, the stock of grass food is limited, and unless Greens are compensated for the amount taken out of the ground by the grass, they will deteriorate. Experiments have shown, however, that no definite standards hold for all soils.

To make well-balanced manures it is necessary to have some knowledge of chemistry and to know the type of soil to be treated. The mixing, too, is important, as reactions take place, and some of these cause loss of value in some of the ingredients and possibly render them useless.

The various elements considered absolutely necessary for plant growth are divided into two classes; those derived from the atmosphere, and those extracted from the soil. Thus carbon, oxygen, hydrogen, and nitrogen are obtained from the air and water. Nitrogen, magnesium, phosphorus, iron, potassium, sulphur, and calcium come directly from the soil. The lack of any of the qualities affects the growth of the grass, and the fertiliser must supply this lack and so restore the balance. Those usually lacking are nitrogen, phosphorus, potassium, and lime.

Sulphate of Ammonia. A quick-acting and powerful nitrogenous manure, the best time to apply is in early spring. Sow at the rate of ½oz. to the square yard, mixed with three or four times the bulk of soil or sand. Should be used with considerable amount of discretion. For instance, where soil is deficient in lime this fertiliser should not be applied, as it has a tendency to exhaust the soil, and if extensively used will produce an acid condition.

Dried Blood is a nitrogenous artificial fertiliser for late winter or early spring use. Its action is gradual. Favourable for sandy, loamy soils, and should be used at the rate of 3 cwt. per acre.

Nitrate of Soda encourages the stronger grasses, and should never be used where they are not required. Where its use is desirable a light dressing in early spring will assist in hastening growth by furnishing available nitrogen before the conditions are favourable for the process of nitrification. Should be used very lightly, not exceeding 1½ cwt. per acre.

Peruvian Guano is considered a " complete " manure, containing three chief elements, organic nitrogen, phosphoric acid, and potash. This useful fertiliser is best applied in the spring, especially on soil of sandy nature, using about 2 oz. per square yard.

Fish Guano. The value depends upon its analysis, the two most valuable constituents being phosphate of lime and nitrogen. Not recommended where clovers are objected to. Although this element

stimulates both clovers and grasses, care should be taken to see that it contains a fair amount of nitrogen.

Soot is a rapidly acting nitrogenous manure, which especially encourages the growth of grasses. Its great drawback is that it remains on the grass for a considerable period and stains golf balls.

Bone Meal, Dissolved Bones, and Bones (½in.) are generally looked upon as phosphatic rather than nitrogenous.

The first and last named act slowly. Unfortunately there is a great risk in their use, as they invariably encourage a growth of clover. Quantity varies from 2 to 6 cwt. per acre.

Basic Slag is a non-acid phosphatic manure, a by-product from steel manufacture, from ores containing phosphorus. The growth of clover is promoted in a remarkable manner, and, as clover fixes free nitrogen, basic slag not only gives direct increase in lime and phosphorus, but also indirectly adds to the amount of nitrogenous plant food. On soil which is deficient in lime a dressing of basic slag may give greater results than superphosphate. This cheap and useful phosphatic manure is extensively used on heavy soils, applied in autumn or winter.

Phosphorus does not occur in free state in nature, but exists combined as phosphate.

Muriate of Potash is, as the name indicates, a potassic fertiliser, and when applied, especially on light soils, where it is generally most needed, its action is lasting and somewhat slow; 1 cwt. per acre is the utmost that should be used.

Sulphate of Potash of high grade contains about 54 per cent. of potash, and is a useful manure for applying to land deficient in that constituent. It is, however, very apt to encourage a growth of clover, besides which it is generally too expensive to admit of universal use.

Kainit, although frequently employed alone, is as a rule best used in conjunction with phosphatic manures. It contains from 12 to 14 per cent. of potash, hence its great tendency to promote a leguminous growth; 2 cwt. per acre is a suitable dressing.

Lime is a name given to oxide of calcium, it improves the physical nature of the soil by setting plant food free, by correcting acidity, and by tending to eliminate toxic materials. Insufficient sanitation of the soil is attributed to acidity and various fungoid diseases, but where proper drainage and aeration are encouraged, and a liberal supply of lime is in the soil, it is very rare these conditions arise.

Rape Meal is highly esteemed, not only as a top dressing for young grasses, and newly-sown Greens, but also on old turf in early spring, autumn, or winter. It is somewhat quick in action, and the effect of applying it is only temporary. It may be used on all soils at the rate of 8 cwt. per acre. It is nitrogenous in character.

Farmyard or Stable Manure. When preparing the ground for seed or turf, spread over the surface and dig or fork into the soil in such a way that the bulk of it remains within two or three inches of the surface. Apply at the rate of about 30 tons per acre. Also indispensable for compost.

GEORGE A. KINNEAR.

Essay Competition for 1926.

By R. WILLIAMS,
Rhyl, N. Wales.

CONSTRUCTION OF (a) PUTTING GREENS.

IT is essential for successful construction of Greens to have a good understanding of the nature of the soil, the natural species of growth (grasses, weeds, etc.), and the local weather, and aspect, conditions of the land where the Greens are to be constructed, also thorough knowledge of the game. When sites for Greens have been chosen for a 9 or 18-hole Course, a number of kinds of soil can be distinguished. The following types are commonly met with:—

SANDY SOILS: Are mainly composed of sand and gravel, they are known as "light" or hungry, because they are poor in all plant food, deficient in humus, hold little water, and soon dry out. They are the best class for Golf on account of their drying rapidly in winter, and with proper treatment can be made quite good.

LOAM SOILS: These are soils of intermediate texture, and includes soils of different qualities, sandy loam, medium loam, etc. A good deep loam is rich in humus, and if properly drained it dries quickly and does not dry out in the summer; it also retains manure well.

CLAY SOILS: Are the most difficult to deal with, require careful handling, are known as "stiff" or "heavy," require thorough drainage, although requiring less organic manure than sandy soils, and are usually deficient in nitrogen, lime, and phosphates.

All sites of Greens should be thoroughly drained. Heavy ground should be drained at a specified depth by drain pipes, some clinkers should be used to ensure that the soil above the pipes is porous. Drainage, whilst carrying away stagnant water (which sours the soil), admits the rains, promotes soil aeration, and makes the soil warmer, and so assists the chemical changes of the nutrients which are absorbed in soil water and taken up by plant roots. The better the land is drained, the more it will withstand drought.

The ground also must be thoroughly cleaned of worms and insect pests. Worms are one of the turf's worst enemies, covering it over with slimy casts, etc., making the surface soft, and seed beds for weeds. A healthy soil discourages the below-ground pests, which without filth, sourness, etc., cannot exist.

A wet soil can be mechanically and chemically improved with an application of sifted breeze, sea sand, well-rotted straw manure, and carbonate of lime.

An experienced Greenkeeper makes up his mind as to the quality of the sites, as he walks over, almost by instinct, and he bases his estimate of the soil's value to a large extent on the condition of the growth, grasses, weeds, etc.

The following are a few examples:—

Daisies, plantains, and dandelions show poverty of the soil. Common sorrel, bindweed, mayweed indicate a thin soil and lack of fertility.

Sheep sorrel, gorse, and common buttercup shows signs that the soil is deficient in lime.

Common rush, sedges, and horsetail soon disappear when the land is properly drained.

Moss may be due either to the soil being too retentive, inadequate drainage, or poverty of soil. Yorkshire fog, quaking grass, dock, are indications of neglected land.

Whenever perennial rye-grass, rough-stalked meadow grass, and meadow foxtail are indigenous, it is fairly certain that the land is good.

The success of the constructional work depends a good deal on the weather and aspect. A little knowledge of meteorology is always helpful, and also the best seasons for doing the work, In a locality where the rainfall is very low, everything should be done to aid nature, the soil should be "made" that it would conserve moisture, and an adequate supply of water always close at hand, and it is essential to have the work completed and the sward well established before the spring.

One site for Greens may be facing north, another the east; one may be on high ground, and another on very wet low ground, etc., etc.

Every site calls for different treatment, and for all Greens to be done well the sites must be supplied with good qualities, and quantities of soil, manures, seed, or turf free from weeds; also labour and tools should not be stinted. In constructing Greens every advantage must be taken of the ground, working with and not against Nature, adapting to the natural features of the surroundings near the site as much as possible; but should the ground be flat and uninteresting light undulations could be made, and their character should be governed by the approach shot from centre of Fairway (or Tee), and also they would make it necessary for a player to use this "head" to get a correct line for each putt for the hole. Avoiding any sharp ridges, and unnatural " 'umps and 'ollows," but making the surface of the ground so that a hole can be cut at any place in about three-quarters of its area, so that it would be possible to be frequently

changed, and at the same time for the hole to be cut out in a position that would give almost a level yard all around it.

Should the site want draining, the ground part making, or a raised artificial plateau green be required, the ground should be prepared some time before the seeding or the turfing season arrives, and so let the soil consolidate naturally, and frequently going over the ground with a Dutch hoe, which destroys the weeds, prevents the escape of a lot of the moisture from the soil, and helps to keep the soil in good tilth.

The work of constructing a Green could proceed as follows: A botanical analysis of the herbage of site is made, then marking out the whole area for Green, marking out the turf with a machine, or with pegs and lines 1ft. apart (width), and cut with edging knife; removing the lines and placing them at right angles to their former positions, so marking out the lengths, 3ft. long for rolled, and 18in. for flat turf; then cut and lifted 1½ins. thick with turfing irons, and barrowed away to a place at one side, where they would not interfere with the view of lie of the ground while carrying-on. Should the botanical examination not prove satisfactory, a chemical and mechanical analysis of the soil is made, then drainage (if necessary) is proceeded with (the top spit soil being also removed well away to one side). When completed, a rough, undulating level is made with the subsoil. If the turf is no good for re-laying it may be laid over the area grass-face downwards, or removed and made into lime compost. The top spit soil is thoroughly cleaned, the whole passed through a ¼in. mesh screen, and evenly spread over the area. The top spit soil should be of good quality about 6in. deep, then raking the surface repeatedly until the surface is about right. If the soil is deficient in lime the quantity of carbonate of lime that it requires is evenly broadcasted and lightly raked in. The ground is then left until it has firmly settled.

Then adding organic manure (if necessary), sifted well-rotted straw, or leaf mould lightly forking (not too deep) it with the soil.

Then treading, raking, and rolling until the surface has become quite true and firm, making the undulations look natural as if they belong to the ground, that when the Green is completed it could be cut with a 19in. "New Empire" mower, evenly from any direction. The surface should hardly show the mark of the feet when walked on.

The shape of Greens should not be in squares nor correct circles, but rather of natural irregular lines, so that the Fairways could be cut and merge imperceptibly with them.

The best ways of providing the actual sward for Greens is by sowing with the finest dwarf species of grass seeds, or by laying with turves of (flat) 1½ft. long, 1ft. wide, and 1½in. thick, or by rolled turf 3ft. x 1ft. x 1½in. The best season for sowing

the seed is at the end of August or early September. The soil is at that season warm, also rain and dew are expected. The light soils are then moist, and the loam and heavy soils are not excessively wet, which is of great benefit to quicken germination of the seed, and the young grasses get well established before the frosty weather sets in; also there are fewer weeds growing at this period. About 1oz. per square yard is required for the formation of new turf, but this quantity may be increased where it is considered necessary; it would greatly help to keep down weeds. Choosing a fine, calm day, raking and cross-raking the surface lightly, half of the quantity of the seed is sown from north to south, and the remainder east to west, then covering lightly with a dressing of sifted soil, rolling and cross-rolling with a light roller.

The mixture of grass seeds should include the following species:—Red fescue, hard fescue, sheep's fescue, fine-leaved sheep's fescue, bent (stolonifera), and for heavy soils rough-meadow, and for light soils smooth-meadow grasses, mixing the different types in suitable proportions, considering the soil. The young grasses should not be allowed to get "winter proud"; when they are about 2in. the Green should be rolled with a light roller (this aids root development), and when the grasses are about 3in. they should be scythed. It is very important to lightly roll (varying the direction north to south and east to west) frequently with discretion, also regularly mow, with mower high set and in perfect running order, etc. In mowing, the Green should be cut in different directions every time, with the wind blowing across, otherwise it grows thin instead of spreading out and covering the ground. Any bare, thin patches should be raked, seeded, and rolled in the usual manner, and all weeds eradicated while quite small, otherwise they develop quickly.

TURFING.—The turves should be cut flat, 1½ft. long, 1ft. wide, 1½ins. thick, or rolled 3ft. x 1ft. x 1½in.; they "knit" much quicker than the thicker cut turf; all weeds should be eradicated before laying. The surface of the Green is made exactly like that for the seeding, firm and true, and lightly raked. The turves should be composed of fine-leaved fescue, certain species of meadow and bent grasses according to soil conditions. Lay the turves with forks, packing them as closely as possible together, and beating them gently down with turf-beater, mixing a few pounds of the finest dwarf species of grasses with specially prepared sifted soil, and broadcasting the compost evenly all over the Green, working it well into the turf and joints with the back of a wooden rake, and lightly removing surplus soil with a birch besom, rolling and cross-rolling with a light roller. Allow about six weeks for the turf to "knit." The Green is regularly mown, seeing that the machine is in perfect cutting order and

set high (excepting when the weather is frosty). In mowing, the direction is varied according to the wind; also rolling occasionally in different directions.

The turf can be laid down at any time between the end of August and the end of January (weather permitting).

In dry areas it is of great importance to have the work completed early, on account of the possibility of drought occurring in the spring.

CONSTRUCTION OF (b) BUNKERS.

TO provide an interesting game for all classes of players there should be comparatively few constructed Bunkers on any course, but every Bunker made should have an influence on the line of play from the Tee to Green. Bunkers should not be placed to punish the very bad shots, which, as a rule bring off their own punishment, but rather to punish the "ordinary" shots and reward the really good ones.

There are two classes of made Bunkers:—Bunkers built above the ground level, and pot or sunken Bunkers.

Bunkers should be made wide and deep enough to trap and hold an ordinary bad shot, but in a way that would give a player, from anywhere in it, a reasonable chance of getting out in one stroke.

They should be made to appear as natural as possible, the banks and hummocks should be made with a gradual and continual slope, which means that for every foot raised above the ground level about 5ft. of ground would be required to make up the necessary slope, so that a "Triple" mower or a hand machine could be got over them, therefore saving much time and labour of scything. When it is necessary to construct a raised Bunker, through defective drainage, such a Bunker can be made as follows:—

Marking out the desired shape, not conforming to any sharp angles or curves, but rather to make it appear as if the wind, etc., had made it naturally. Taking off the turf on the outside of Bunker area (using pegs and line) with turfing irons, and for every foot raised 5ft. in length of turf would be required, so that it will disguise the fact that the sand (when finished) in the Bunker is above the surrounding ground level. When all this turf is taken up, barrow a little away, where it will not be in the way whilst construction is in progress. The turf from the Bunker area could be used for the facing of Bunker, which is required so that it will prevent the wind from blowing the sand out, and also prevent the players, who will scramble out of a Bunker anyhow, pulling the sides down.

Cutting the turf with a spade in blocks of 8in. x 8in. x 4in. soil (using pegs and line), and by drawing the handle of spade towards you, the blocks can in this way be cut to any angle for the slope of bunker face. Then making a solid foundation (and

placing the soil on the required raised surface slope), for the laying and building (like ditching) up with the blocks, for the sides of bunker, packing them closely together, and filling up firmly behind them with soil from the Bunker. When the desired heights are reached, and all the turf is taken up from the Bunker area, the soil is used for making up the ground for a gradual slope with the surrounding level, avoiding hollows, or sharp ridges, etc., treading and rolling, making the surface quite firm (so that a Triple mower, etc.). The turf is re-laid and trimmed off at the Bunker sides. Sea sand is put into the Bunkers, and raked well up the sides, and at the further corner from the line of play Marram grasses are planted to make it look natural. The character of a Course depends a great deal on how the Bunkers are placed. Each hole should be Bunkered differently, and with every advantage taken of the ground, etc. For the long holes cross bunkers should be avoided as much as possible; although their distances can be varied from the Tee, and provide a certain amount of test of skill, their continuance gets too monotonous. A fair carry for Mr. Abe Mitchell would be, perhaps, quite unfair to the scratch player, and the same difference would apply between the low and double-figure handicap player. For providing an interesting and better test of golf to all players, Bunkers could be constructed as follows:—A line of Bunkers could be placed that they have to be closely circumvented rather than be carried; at another hole a Bunker could be placed that a long driver could carry, and the short player would have to circumvent; and again at a dog-legged hole, so placed that the more direct the line for the hole taken for drive, the longer would be the carry. But in every case the more accurate the shots are placed, the greater the reward in an easier shot for the approach.

The width of a Bunker should be about one-third of its length, and the depth according to its length and width. On seaside Courses one sometimes sees Bunkers faced with wood, which are very dangerous; players have been known to lose the sight of an eye through them. A better facing that would hold the sand is the turf blocks and planting of Marram grasses. (If sheep graze on the Course, small mesh wire-netting could be fixed on.)

CONSTRUCTION OF (c) TEES.

On account of the hard wear Tees receive, much more than at any other part of the Course of similar area, and especially at the short holes, where divots are knocked up with practically every shot played, at least three well-constructed Tees of fair sizes should be made for every hole.

No. 1 Tee should be for the standard length for the hole, kept specially for the monthly medal competitions and other

special meetings, etc., its length and width made according to the amount of play that it would be expected to receive.

The rear portion played from when the wind would be favourable, and a part of the front of the Tee played when the wind is blowing against. The Tee plates or boxes always moved at least two yards every day while under play.

No. 2 Tee for ordinary days' play when the wind is favourable, and the length to hole slightly shorter than from No. 1 Tee.

No. 3 Tee, more forward, should be played from when the wind is against.

The Tees should be constructed slightly away from each other, in the old army formation, "en echelon," so that when two of them are "resting" and under repair also, it would not be necessary for anyone to walk over them, and their altered positions would bring different character for the hole as each of the Tees are brought into play.

The correct way of constructing the Tees for the line of play is as follows:—A stout peg is placed in the centre of the site; then measuring half its required length to the front, and half the length to the rear, and placing at each of these points another peg; then getting the three pegs in a direct line to a place where a full drive is expected to reach by a scratch player, or centre of Green, just according to the length of hole; then measuring half its required width to each side of the front and rear pegs, and at each of these four places pegs are placed, using a line, and running it around the outside pegs, marking out the whole area with a turfing or edging iron.

If a Tee is to wear well, it is absolutely necessary that the Turf shall be quite firm. Soft, damp turf is an abomination to the players, who are not able to take up their proper stance, on account of the turf giving, and also not swinging the club correctly; and to the Greenkeeper on account of their wearing out quickly; and also means heavy pushing work with the hand mower.

It is, therefore, essential that the soil shall be made porous, and that it cannot hold moisture in excess; if there are any worms or other pests these should be first of all exterminated. The question of drainage is nearly always a vexed one, and nearly every site calls for different treatment when no pipes are available.

The first step generally would be to remove the top soil to the depth of about 18in., into the bottom of which would be thrown about 6in. of clinkers, etc.; on this a layer of old turf is put, grass-side downwards, then filled in with good loamy soil, which has been freely mixed with charcoal and sea sand or fine breeze.

A well-constructed Tee raised above the surrounding level would greatly improve drainage, and the work could be carried out as follows:—

First of all marking out the area correctly for the line of play, and should the turf be unfit for re-laying, it could be used for building up the sides. Using pegs and string, the turf is taken up in blocks with a spade, 8in. x 8in. x 4in. (soil). When digging the spade into the ground, the handle should be drawn slightly towards the digger, so that a gradual slope is allowed for the sides. A firm foundation is made a little to the outside of the marked area, so that when the sides are built up the Tee conforms to the required size (length and width). Building up the sides (like ditching), packing the blocks closely together, and filling up with sandy or light loamy soil to the desired height, allowing at least 3in. of good surface soil, manuring and liming if required. The ground is then left for at least six weeks until the soil has fairly settled, then raking and rolling until the surface is quite firm and true. The right sort of turf, of hard-wearing qualities, should consist of the following species: The fine-leaved fescues, marsh bent (stolons), and dwarf meadow grasses, but if the correct old turf cannot be found seed should be sown containing the above species. The work completed exactly like the seeding or turfing of the construction of Greens.

To the majority of players the greatest pleasure in the game is to watch the flight and finish of a well-struck ball. Blind holes should be avoided as much as possible; too many make play as if one is playing in a fog.

A raised Tee is very useful for this purpose, and especially at the short holes, where all the turf and the bottom of the flag should always be visible so that a golfer can play for the " pin," and not merely for the Green. On seaside Courses raised Tees are not always advisable, unless a good supply of water is close at hand, for in the summer or during a short period of drought in spring, they soon get burnt up, and become unplayable. A useful Tee for seaside Courses, especially if there is the trouble of blown sand continually occurring, is the Mat Tee, which can be laid flush with the ground, or when required can be constructed to a good height by the making of a raised platform (if there isn't a suitable sand bank near by) with old railway sleepers, timber, and filling up the inside with sand or soil, making the surface level, and set for the correct line for hole. Steps can be made with short sleepers laid lengthways, filled with soil, and turfed, for walking on and off the Tee. The size of mat should be 6ft. x 6ft., and a special wooden tray made to hold it. The tray should be fixed on to the raised structure, and the mat must be thoroughly dry and placed within. Then three barrow-loads of dry sand, that will run freely through the fingers, is put on the mat, working it well in with a stiff broom, until it is ab-

solutely saturated and appears lost. The more fine sand it is given, a firmer, and an unresisting Tee will result, so that the players would hardly notice that they are playing from mats; it "gives" just correctly to the feet, and it is playable at all seasons.

THE IMPORTANCE OF FEEDING TURF.

The ever-increasing popularity of golf demands that the turf of the Tees, Fairways, and Greens should be in as perfect condition as possible all the year round, with the exception of when frost and snow intervenes.

With the amount of play on the Golf Course there would soon be an all-round impoverishment, and later bare patches would prevail, without wise feeding of the turf.

Experience teaches us that turf that has been brought into a fine condition after about twenty years' regular fertilising, etc., would revert in three or four years to weed, "scrub," etc., if neglected. The old adage could be revised: One year's neglecting; seven years' correcting.

The growth of the right species of grasses on the Course is really a struggle for existence between them and various coarse grasses and weeds, so it will easily be seen how necessary it is that the soil should be healthy and properly fed.

In soils four elements constitute an important group, the deficiency of any one of which is a factor limiting the growth of grasses: Nitrogen, phosphate, potash, and lime (the remaining elements also essential to their growth are available in sufficient quantities). The aim of a Greenkeeper is to maintain an adequate supply of those elements which are liable to be depleted by continuous growth and cutting.

When it is necessary to mow Greens with machine and box, a low estimate of about two crops of hay is taken away, that a farmer would receive from a similar area in a season. The soil in consequence is heavily taxed, and to support a good turf the ingredients taken up by the grasses must be replaced by judicious feeding.

When sheep graze on the Course they bite closely, picking up their "keep" from the fine-leaved bottom grasses, not the coarse species, therefore causing a rapid deterioration in the herbage. Sheep grazing encourages the growth of the creeping thistle; they leave behind them only what has to be cleaned and swept up (besides scalding and fouling, etc., the turf), another reason that turf requires continual attention and feeding.

One of the chief causes why moss is prevalent on some turf is poverty of the soil. The remedy, then, is obvious—a good grass fertiliser.

In time of drought it is essential that an adequate supply of water is close at hand, for to live grasses must have water to

drink. When artificial watering has to be given, the evaporation that ensues causes the high places very soon to get burnt, and also causes a parching effect on the turf and some exhaustion to the soil. The turf then requires a little attention and feeding, mulching, applying clean grass cuttings only, or a small quantity of soil mixed with a little complete grass fertiliser, broadcasted in the evening before the watering, helps to keep the ground cool, and also prevents the too-rapid evaporation. It is an error to suppose that walking always improves the surface of turf. It sometimes receives very rough usage (Tees and Fairways, Divots, etc.), especially on the Greens, from golfers and caddies' feet, when they are not shod properly, soles and heels studded with nails. Some drag and do not pick up their feet properly when walking; also drawing a foot back or jumping in excitement when nearly or holing out a fairish putt. Also the turf (Greens) gets damaged when the clubs or pin are carelessly thrown on the ground. A considerable toll is in this way taken out of the life of the grasses, so it will be readily seen how important it is that the turf should be constantly fed, to promote fresh growth and make up for what is lost. Top-dressing and fertilising will be found very helpful to keep a true and porous surface (in most cases); also giving the necessary nourishment for the grasses.

The grasses need several earthy materials of which the earth crust is composed. These three are essential (the others are abundant), namely: Potash, phosphate, and lime. Sandy soils are very poor in these foods, therefore they require regular feeding. When the soil conditions are adapted for normal growth of grasses the turf is then relatively immune from attack by insect and fungoid pests. All the food is taken up from the soil and passes in liquid form into the roots. Thence it is carried up to the leaves, along with food taken up by the leaves from the air. Quite a large part by weight of all grasses comes from the air, but unless the soil is well managed the grasses cannot avail themselves properly of this food. As the air above poor soils is just as good for grasses as the air above good soils, it is important to feed the poor soils by supplying what is required. This very important substance is called nitrogen. An important factor in the feeding of turf is thorough knowledge of the soils, indigenous growth and climatic conditions. Three Greens within a few hundred yards of each other, yet the nature of the soil, aspect and their formation, may be entirely different, and each requires individual treatment. Of great importance is to keep all soils in as neutral condition as possible; either a too-acid or an alkaline soil interferes with the growth of grasses.

Without a good understanding of nutrition, much harm may be done; therefore it is essential to know the chemical and the mechanical conditions of the various fertilisers used, and also their purchasing values.

With patience, systematic, and judicious feeding, a dense, healthy sward of the correct dwarf species of grasses can be obtained, resulting in the perfect turf.

Nitrogen is required for the actual growth of the leaves of grasses, and the grasses depend upon the amount they receive to check the growth of clovers and weeds.

Phosphate is required to help root development and check the growth of coarse grasses, and help to keep them healthy.

Potash is an element essential to formation of starch, etc., of grasses, and an aid to increase their disease-resisting capacity.

Lime is mostly a soil food, keeping the soil sweet and in a healthy condition for the roots of the grasses to live in.

THE VARIOUS FERTILISERS THAT CAN BE USEFULLY EMPLOYED.

There are two main classes of fertilisers essential for feeding the turf on Golf Courses :—

(1) Natural (organic)—well-rotted straw, leaf mould, etc.

(2) Artificial (inorganic)—neutral sulphate of ammonia, superphosphate of lime, and sulphate of potash, etc.

(1) Improve the soils in two ways :—The organic matter (vegetable refuse) present alters the texture of the soil (adding humus), making it a more suitable home for the roots of grasses.

Improves the fertility, by replacing the ingredients that grasses remove during their growth.

(2) Natural manures cannot be relied upon alone to keep up the soil to a perfect state of fertility. Artificial fertilisers do not add humus to the soil, but they improve the fertility of the land by adding to it the ingredients required, therefore keep the grasses growing.

As in the case of human beings, more harm is done by over-feeding than by under-feeding, for the grasses are not greedy, and one should know how to feed them cheaply. On the golf links it must be remembered that it is always advisable to encourage the "finest" dwarf species, and not the coarse grasses. Great care should, therefore, be taken in the use of fertilisers (the individual requirements of each of the Greens, Fairways, and Tees must determine the amount to be given), and so avoid the treatment doing more harm than good. Coarse grasses mean much labour in cutting, and they will eventually become bare near the ground.

Leaf Mould Manure (Natural).

A valuable organic manure for preparing ground or top dressings.

Its supply of vegetable matter maintains the necessary organic content (humus) in the soil. Contains the essential elements of plant foods, nitrogen, phosphate, and potash. Heavy soils are improved in quality by annual dressings, and the light soils are rendered more compact and retentive of moisture by applications of this when well rotted and mixed with a little soil, and riddled through a ¼in. mesh sand screen. Gradual, gentle, and lasting for all classes of soils, best applied autumn or spring, and worked into the turf with the back of rake.

The more humus in a soil, the greater retentive power it has to hold moisture. It is estimated that 100lb. of humus will absorb and hold about 150lb. of water, while the same weight of ordinary soil will hold only 30lb. of water. Organic feeding of the turf, therefore, increases the amount of humus in the soil, and improves soil texture.

Lime and Turf Compost (Complete Fertilisers).

A compost heap is made as follows:—

In the spring all the useless turf is collected, first placing a layer of soil of about 1ft. thick; on the top of this a layer of old turf should be placed, and then spreading a layer of finely ground limestone, layer and layer about (turf and lime) to about 5ft. high, and then the whole well covered all over with soil of the links. During the end of summer the heap should be turned over two or three times.

In the early autumn the whole should be passed through a ¼in. mesh screen, placed under cover, and spread over the Greens any time (weather permitting) before the end of January (and the "seconds" could be placed over the Tees), then well brushed it with a besom.

Valuable top dressing for all classes of soil, especially for light and sour Greens, contains the necessary grass and soil food. Fairly slow in action, but is lasting. Makes light soils less porous, and helps to retain moisture. Renders heavy soils more porous and warmer. Enriches the soil, having organic matter.

Well-rotted Straw Manure (Organic).

Is very valuable for preparing ground for the Tees and Greens, and also top-dressings for same. Adding the necessary humus to sandy soils (which are poor, hot, and dry), and renders them more retentive of moisture, and the grasses do not suffer to the same extent during dry weather. Heavy soils are poor, cold, and wet, and require humus. Fairly quick, gentle, and lasting for all soils.

Should be passed first through a ¼in. mesh sieve, evenly and lightly spread over the turf as top dressing, and well worked in

with the back of rake. In districts of high rainfall, best results can be obtained by dressing in spring; on the other hand, in drier conditions, 30in. or less of rain, late autumn would be likely to give best results.

NEUTRAL SULPHATE OF AMMONIA (Inorganic). Soluble nitrogen. Contains about 21.1 per cent. nitrogen, free acid max. .025.

A British production. The best and cheapest per unit of nitrogen amongst other nitrogenous fertilisers for golf courses. Valuable where there is sufficient carbonate of lime in the soil to convert the sulphate into the carbonate of ammonia, and the presence of humus to absorb the carbonate of ammonia. It is similar in mechanical condition to Demerara sugar, but runs freely through the fingers like dry sand, so that it can be evenly broadcasted by hand. It is of all foods (nitrogen) in which the soil is often most deficient, causing the fine grasses to get starved, and then the possibility of weeds developing.

Growth: Grasses, used in excess, coarse grasses.

Action: Changes fairly quickly in the soil, by the action of bacteria, to the nitrate condition, and a marked improvement in the turf can be noticed in about 14 days. Can be applied during the growing season, when required, in light palatable dressings, mixed with three or four times its own bulk of soil, or preferably sea sand, during showers, or watered in. Throughout the whole period of growth incessant demands are made upon the soil for nourishment, and for this reason this fertiliser is much preferred to other nitrogenous fertilisers, owing to its less active action. Quicker acting tends to produce a rapid growth, which, if suddenly checked through exhaustion of supplies, becomes weakened, and the turf is then more liable to attacks by insects and fungoid pests. Daisy, and other dwarf-leaved weeds can be checked by its application, and bring about a permanent improvement in the turf. On sandy and light soils has the tendency of making acid. The trouble can be entirely remedied by a dressing of carbonate of lime, which in any case is often desirable on light soils. May be mixed with superphospate, and most forms of potash.

SUPERPHOSPHATE OF LIME (Soluble Phosphoric Acid).

Phosphate, one of the essential elements of plant food, is the source of phosphorus in plants, promoting root development and early development of young growth. Although it contains no true lime, it contains calcium phosphate, and gypsum. British superphosphate of 30—35 per cent. is much preferred to the imported material, being in a much purer state. One cwt. requires only about 4lb. of carbonate from the soil to combine with its free acid.

Growth: Grasses and clovers; also counteracts any

rankness of growth brought by applications of nitrogenous fertilisers.

Responds fairly quickly with all soils, and though soluble in water it does not wash easily out from the soil, it becomes distributed and fixed; it must be in a fine state, free from any lumps. Best applied in small quantities at any time during the growing season, during showers or watered in, with three or four times its own bulk of soil or sand; has the tendency to "burn" the herbage if applied too thickly.

While much depends on the soil (a clay soil requires more phosphates than a sandy soil), a good deal depends on the rainfall; a district receiving 30in. or more of rain is in greater need of phosphates than in districts with lesser amount of rainfall. When the presence of moss in the turf is due to poverty of soil, it is best eradicated by a severe raking with an iron-rake, and given an application of this phosphate.

Mixed with neutral sulphate of ammonia is a valuable fertiliser for heavy soils, which usually contains potash in sufficient quantities.

POTASH FERTILISERS (Soluble).

POTASH alone is not recommended as a dressing for Greens (although light soils are mostly deficient of this element), as it tends to burn the herbage, encourages grasses and clovers. In deciding which form of potash to use for mixing with neutral sulphate of ammonia and superphosphate, to make an ideal complete manure, the main factors should be the price per unit of potash (K_2O). But should a supply be purchased for a season the best form would be sulphate of potash (48 per cent. potash), which stores much the best.

Indications of the presence of potash in the soil disclose the following indigenous species, that would comprise the greater amount of the herbage: Meadow fescue, rough or smooth meadow, perennial rye grasses, etc.

KAINIT, about 14 per cent. soluble potash.—Grasses and clovers. On poor deteriorated Fairways of light soils, with the clovers.

On poor deteriorated Fairways of light soils, with the excess of weeds, daisies, and other mat weeds, the herbage can be greatly improved by an application of this potash, mixed with superphosphate, and broadcasted early in the spring. Since salt contained in kainit is not, in ordinary dressings, detrimental, but usually rather an advantage to turf, kainit will often be the most economical source of potash. On Golf Courses one often comes across large groups of stinging nettles (which interfere with finding of balls); these can be destroyed by spraying with a 15 per cent. solution of kainit. The spring would be the best season to apply. The young nettles would become black, and the shoots die off, and grasses would gain the mastery.

Carbonate of Lime (Calcium Carbonate), solution gradual.

Carbonate of lime often fulfils such a number of functions in the soil that it is regarded as a soil improver; very little is required really by the grasses, etc., as food. It is mainly a soil food.

Sweetens sour soils, breaks up organic matter, and hastens the process of nitrification (the change brought about by fermentation or bacteria.) Makes sandy soil less porous, and helps to retain moisture. Improves the nature of heavy soils, making them more open and warmer.

Growth: Grasses and clovers; used to excess, clovers.

Action: Fairly slow, better results in the following season may be expected from an autumn than from a spring dressing, and may be applied any time without fear of checking the growth of grasses. A most pronounced feature of turf requiring lime is the presence of thick mat of undecayed plant remains on the surface of the soil. This mat can be easily seen by cutting out a sod with a spade. Such mats form most easily on light soils, growing a great deal of bent grasses, sorrel, etc. Considerable losses occur yearly through rain and soil water being charged with carbonic acid gas, which exerts a considerable action in dissolving the lime contained in the soil. Some of this dissolved lime is constantly finding its way into the drains, and thus lost to the soil; some fertilisers also increase the loss. It is essential, therefore, for all soils that these losses should be made good by an occasional application of carbonate of lime.

By removing soil acidity it has very beneficial effect on the development of those bacteria which convert organic matter of the soil into soluble food for the grasses.

Ground Mineral Phosphate (Insoluble Phosphate).

Finely ground, contains about 85 per cent. of phosphate of lime. Should be applied if possible on heavy soils retentive of moisture, during June or July. Rushes, sedges, and iris, which indicate wetness, would gradually disappear when treated with this phosphate; would promote a better herbage, and would also bring about much drier conditions.

Sea Sand.—The value of sea sand lies chiefly in the proportion of carbonate of lime that it contains, which is derived from the decomposed shells. On rich loams and clayey soils a good tonic and renovating benefit will be given to the turf by proper dressings of sea sand, finer grasses taking the place of the coarser species. Typical weeds of an acid soil, sheep sorrel, silverleaf, etc., are also successfully dealt with. It also aerates the turf causes it to play firmer, and drier in the winter; worm casts are more easily brushed off, resulting in a cleaner, firmer, and drier surface.

Bone Charcoal contains a little phosphates, is very bene-

ficial when applied on soil of very retentive nature, it acts like a filter, neutralises any acidity, aerates, and improves the texture of the soil; is then not so wet during the winter, and a more desirable rooting is produced, resulting in a much firmer and drier surface.

SYNTHETIC UREA (soluble nitrogen) contains about 48 per cent. of nitrogen, is really worth experimenting with, because of its being rich in nitrogen, reducing transport charges, stores well, does not take up moisture from the air; therefore, always in good condition for dressings; and lastly free from injurious materials. It is perfectly safe to use, mixed with about 6 to 8 times its bulk, with soil or sand.

A COMPLETE GRASS FERTILISER.—A compost of neutral sulphate of ammonia, superphosphate of lime, and sulphate of potash, mixed as required from three or four times its bulk of soil or sea sand, or to a cartload or more, well riddled, is, perhaps, the finest artificial fertiliser obtainable for the Greens, Tees, and Fairways (the latter if funds allow), requiring a material consisting of the chief elements on which the growth of grasses depend: Soluble nitrogen, phosphate, and potash (and with sand a certain percentage of carbonate of lime). When making a new Tee or Green the fertiliser should be evenly spread over the surface and raked in; it would be then better to leave the ground a few days before turfing or the seed sown. It is best applied for renovating the turf by evenly spreading it over the ground and working it in with a birch besom about three weeks before the active growth. It can also be applied in light palatable doses at any time throughout the growing season, when the turf looks a bit off colour and requires a little feeding. Applied during showers or watered in, allowing at least three weeks between the applications, keeps the grasses in good heart, healthy, and growing throughout the season. The amount of the different ingredients must be so mixed to suit the soil and plant requirements, etc., remembering that in most cases grasses only are required. In making the compost the ingredients should also be very thoroughly mixed in small quantities, sufficient for immediate use. Lumpy manures, before mixing, and the mixtures when made, should be passed through a ¼in. mesh sieve, and the remaining lumps carefully broken up. The complete fertiliser is then much easier to spread evenly on the turf (or soil); not only do lumps prevent much of the turf getting its fair share of the dressings, but the spots on which they fall are poisoned, so that the grasses are weakened or killed outright.

Of hardly less importance than the selection of fertilisers is that they should be stored properly. A little trouble and expense in keeping it fine and dry, and in applying it evenly, will be well repaid.

Top-dressing and fertilising, if properly and carefully done,

need not interfere much at all with the play. Greens and Tees should be firstly rolled with a spiked roller, and Fairways should be gone over with a spiked harrow with tines of about 2½in. By these means the grasses (roots) would avail themselves more quickly of the fertilisers.

THE DANGER RESULTING FROM INDISCRIMINATE MANURING OF PUTTING GREENS.

NITRATE OF LIME (soluble nitrogen about 13 per cent.).

Has great power of absorbing moisture, and much loss may occur in storing for any period over a month; it is very difficult to evenly distribute, and usually has to be carted about in casks. When broadcasted by hand it is necessary for the man sowing it to wear an apron, and grease his hands and arms. The nitrogen in nitrate of lime is more expensive than that in neutral sulphate of ammonia.

NITRATE OF SODA (soluble nitrogen about 15½ per cent.).

This manure is usually very lumpy, and requires crushing before application, and is wasteful on light soils, being readily washed out of the soil. When used on heavy soils it tends to make them sticky. Causes a rapid growth to develop, which readily succumbs to fungus attack.

BONE MEAL (usually 3.75 per cent. nitrogen and 20.6 insoluble phosphoric acid).

Is not an adaptable manure for Greens, very slow in action, and would encourage the growth of clover. The difference between soluble and insoluble manures is the same as £10 due in three years or six months, is not worth £10 to-day; and so with 10lb. of nitrogenous or phosphate manures, which will become effective in a remote future, is less valuable than the same quantity which can be brought into action within a few weeks.

ORDINARY SULPHATE OF AMMONIA (nitrogen about 20.6 per cent.).

Usually is very coarse and lumpy, removes nearly its own weight of carbonate of lime out of the soil, frequently sufficient to render the soil infertile, and does not store well.

SOOT (fertilising value nitrogen, sulphate and chloride ammonia).

Six cwts. of good soot is equivalent to about 1 cwt. of neutral sulphate of ammonia. An application would be of great inconvenience to the players.

BASIC SLAG (insoluble phosphatic manure).

Should not be put on or anywhere near Greens; on light soil of no value would be wasted, and washed out of the soil

before it would become available. On other soils would encourage the growth of white clover.

GROUND LIME. This consists of burnt lime (quick lime).

It quickly absorbs moisture, swells, and bursts the bags, so that it is impossible to store it for more than a week or so, and if at all applied would cause rapid oxidisation.

WASTE TANNERY LIME. Highly dangerous to growth. Contains poisonous substances, sulphites, and sometimes arsenic.

SEA WEEDS (organic manure).

Is not suitable for Greens, is of slow-acting organic nitrogen, very poor in phosphates, but is very rich in potash, therefore would encourage the growth of clovers.

NITROLIUM. A nitrogenous fertiliser of foreign origin, is somewhat inferior to neutral sulphate of ammonia, is not suited for top dressings. Slow in action, and has to undergo decomposition in the soil.

STABLE or FARMYARD MANURE (natural).

To the agriculturist and gardener these may be very excellent commodities, but they are not well balanced nor suitable manures for the dwarf species of grasses required on a Green. They produce a coarse herbage, and also encourage clovers, chickweed, fungus, etc. Closely examining each load of hay, when bought from the hay merchant for the horse, I fail to find any of the valuable fine-leaved fescue grasses, etc. (required for a dense sward). These bottom grasses are of no commercial value to the farmer, but I do find bearded rye, perennial rye grasses, and rough cocksfoot grasses, clovers, and other weeds. Thousands of the seeds of these plants eventually get into the compost heap and mixed with the soil when it is made. The seed may lay dormant for a long time, and may even germinate better after lying in a compost heap.

While preparing dressings, etc., for Greens and Tees, etc., and passing it through a small mesh screen, I have come across a lot of unhealthy looking grubs (near the top of heap, like leatherjackets?), also some very big worms, and vegetable mould. During the mushroom season one usually finds fungus growing on a compost heap; therefore these manures introduce very harmful ingredients into a Green, and may possibly alter its whole character of growth, etc., by their application as top-dressings.

ROBERT WILLIAMS, Rhyl, N. Wales.

Construction of Putting Greens.

By ROBERT HOOD.

The construction of Putting Greens may safely be termed an art, and embraces several matters which may be treated separately, but which are properly branches in the art of making a Green, and cannot be consistently studied and usefully applied without a full appreciation of their several and intimate connections. To be successful in the production of the finished article, these various questions and subjects arise, of which the greenkeeper should have an intimate and up-to-date knowledge. To a great extent the finality of a Green depends on the manner in which the work is executed, and whether all the facts have been taken into consideration. The principal factors to be observed in Green construction are: Design, drainage, nature of soil, grasses, and economy, getting the best possible results at a minimum of cost. A very good plan before proceeding with the work is for the Greenkeeper, for the benefit of himself and his men doing the work, to have constructed out of modelling clay a model of what the Green is intended to look like when finished, showing clearly the undulations and any other natural features he wishes to employ, thus obviating the necessity of doing the work several times over. The point to be aimed at in designing a Green is to make it appear as natural-looking as possible; anything in the nature of geometrical lines should be avoided, the undulations should be irregular, but not exaggerated, rather have it more like a big wave. Avoid making ridges and sharp hollows; the cutting machine will skim the ridges and they will have a tendency to burn up in the summer, while the hollows will get all the moisture, and grow quickly; they cannot be so closely cut, and spoil the uniformity of the Green.

When the position of the Green has been pegged off, should drainage be found necessary, a general survey and examination of the ground will determine to what extent it will be necessary to drain the area; very great attention should be given to this part of the work, as not only a wet season, but a dry season has to be considered, as will be shown later. Drainage has the effect of removing surplus water, and of introducing air, consequently it promotes warmth; the soil becomes porous, and is followed by a disappearance of water-loving weeds, and a vigorous growth of cultivated grasses. The wetter the land, the greater the evaporation, and as a consequence the greater the excess of coldness, and, unless drained effectively, many soils, especially the clays, would be useless for the production of good grasses. It will therefore be seen that too much attention cannot be paid to this aspect of the question. Various systems and methods of drainage are employed to suit the particular case in question, but experiments prove that the system of land drains is most effective and more economical for the purpose in view.

The methods of drainage are determined by the inclination of the surface and the porosity of the soil, and the system best adapted for the purpose is that of the herring-bone formation. The herring-bone formation consists of a 4-inch main drain running down the centre of the Green, with 2½ inch subsidiary pipes running in on either side of it at the angle of 45 degrees, and from 10 to 15 feet apart. If the contour of the surface does not lend itself to the formation of the subsidiary drains running towards the main at the angle of 45 degrees, the subsidiary drains may be run towards the main at right angles; but under this arrangement two imperative rules must be observed, that all the junctions should be curved, and that no two subsidiary drains shall enter the main drain at opposite points. If these rules are neglected, the currents will be interrupted at these points, and mischief may arise from flooding when the drains become filled in wet seasons. Another method adopted to prevent flooding and interruptions is to allow the subsidiary drains to enter the main through an aperture on the top of the main drain, thus allowing the water from the subsidiary drains to have a clear drop into the main; under this method it is also imperative that the two preceding rules apply here as well. The drains are laid in trenches, and the depth of the trench varies according to the porosity of the soil. On stiff or heavy soils the depth should be from 18 inches to 2 feet, and the distance apart is generally from 10 to 15 feet. On light, porous soils, the drains are deeper and wider apart, and in this case the depth should be from 2 feet 6 inches to 3 feet 6 inches, and from 25 feet to 33 feet apart. The drains in this case are kept much wider apart in proportion to their depth, as it is necessary to prevent taking away too much moisture in the event of a dry season. Care must also be taken to insure a progressive fall, in which the pipes lie evenly, an efficient fall being 3-8ths of an inch to one yard. When the laying of the pipes is completed, the pipes should then be covered with a layer of broken stones; this will be found to materially increase the effectiveness of the drain on heavy clay soils. Having now completed the drainage part of the work, and with the model exposed to view, attention is now directed towards the soil formation, and whether the Green is to be turfed or sown with seed. Many people argue in favour of turfing a Green on account of economy and speed; this, so far, may be all right if you have a good class of turf handy, but on the other hand, if you have not, then it is false economy to use turf, and a decided advantage to sow seed. Taking all the costs into consideration, of lifting, carting, and relaying, besides weeding, gauging, and top dressing the turf, a credit balance is to be found in favour of the seed. In any case, whether it be decided to turf or sow seed, the operations in the next part of the work are of a similar nature. There will now be some soil left over after filling up the drains, and if this be anything of an open nature, a chance presents itself here of employing this for making the undulations; get all the undulations and special features made in

the first instance according to the model. After this is accomplished, the whole area is dug over to the depth of one spade depth, turning the soil well over, care being taken to throw out the large stones and all roots of weeds met with in the process of digging; also break up all the big lumps of soil, as the chief object in view is the formation of a seed bed. The digging having been accomplished, the next thing to consider is the nature of the soil for manuring purposes. If the soil be of a heavy nature, stable manure should be employed, but if the soil be of a light nature, then a manure of a more retentive character, such as peat moss, should be used. The amount required would be about 4 cartloads for a Green 20 x 20 yards. The stable manure or the peat moss, as the case may be, should then be spread evenly over the surface of the Green and dug or forked into the soil in such a manner that it is kept within two or three inches of the surface. This having been done, it is now necessary to prepare the seed bed by getting as fine and friable a surface as possible. For this purpose, the clods should be broken up and the stones and roots of weeds should be raked off. After this, the ground should be rolled and cross-rolled, raked and cross-raked, until the surface becomes firm and fine. Before sowing the seed, a dressing of artificial manure will be an advantage in supplying food to the young plants in the early stages of their career, and for this purpose the following dressings will be found useful:—

FOR HEAVY SOILS, use 36lb. of superphosphate, and immediately the growth has started put on 9lb. of nitrate of soda.

FOR LIGHT SOILS, mix together 27lb. bone meal, 27lb. superphosphate of 13½lb. kainit, and when the growth has started put on 9lb. nitrate of soda.

FOR MEDIUM SOILS, mix together 27lb. bone meal, 27lb. superphosphate, 9lb. of sulphate of ammonia, and 13½lb. kainit.

If the manure is mixed with a little dry sand or light soil, it will be easier handled. Distribute it as evenly as possible, and give the whole surface a good rake over. Sow the seed on the raked surface at 1 ounce to the square yard, choosing a dry day for the purpose, and taking care to distribute the seed evenly. The seed has now got to be covered to the depth of not more than a quarter of an inch. As a rule this is generally accomplished by raking and cross-raking the surface lightly; after this, the Green should be given a roll with a light roller, first one way, then across the other way. The seeding process now completed, the Green should be left till the grass has come through the ground. The best time for doing the work is at the end of August or early in September; the soil is warm at that time of the year, and the atmospheric conditions are more favourable; if, however, this cannot be carried out, an early start should be made in the spring whenever the weather permits, sowing the seed early in April. A word here in regard to the selection of grass seeds to employ for Green purposes

deserves attention. The nature of the soil and the environment arises, and Greenkeepers should make themselves familiar with the names of the various grasses in relation to the soil, not only to know them by name for the purpose of buying the seed, but be able to distinguish them when they appear on the ground. The following grasses will make a good mixture for Putting Greens:—

One part Agrostis (vulgaris).
One part Crested dogstail.
One part Fine-leaved fescue.
One part Sheep's fescue.
One part Hard fescue.
Half part Poa pratensis for light soils; Poa trivialis for heavy soils.

We will now assume that the Green was to be turfed instead of being seeded; we have got our drains laid, the undulations made, and the ground turned over to the depth of one spade depth, having broken down all the clods and raked off the large stones and weeds, and are about to put on the stable manure or peat moss as the case may be. It is advisable in this case not to bury the manure; spread the manure evenly over the surface and very lightly fork it in, keeping the bulk of it to the top, and lay the turf directly on the top of the manure; this enables the roots of the grasses to get nourishment straight away immediately the turf is laid. Before laying the turfs, examine them minutely and extract any weeds which may be visible; next, put the turfs into the gauge box and thin any of them down which may be over the desired thickness of 1½ inches. After this work is completed, start and lay the turf on the Green, keeping the edges close up to one another; having accomplished this, beat the turf down lightly with a beater and correct any low corners or pockets that appear in the course of the operations. The turf should then be covered with a compost of finely sifted soil and sand of equal proportions, in which might be added a pound or two of good grass seeds. Take a good birch broom and work the compost into the turf, taking particular care to work it thoroughly into all the joints, then finish the operations by giving the Green a light roll. The best time to turf a Green is in the late Autumn of the year; it can also be laid in the early Spring, but in this case the turf is more subjected to cold, dry winds which has a tendency to kill it.

CONSTRUCTION OF BUNKERS.

The construction of Bunkers is an art where much diversity of opinion prevails, and to understand the subject clearly it is necessary to know what a Bunker is, and the functions which it fulfils. The definition of the word "Bunker," as applied to Golf, may be stated as: A depression in the ground which has been top-dressed with a

light soil or sand, and made in such a manner in which Nature might have formed it. The function which a Bunker fulfils. is to punish a bad shot, but it should be constructed in such a fashion that it should permit of a player having a fair chance of getting out and regaining the Fairway in one stroke. With these points in view, a definite principle has been established, and a few observations in regard to the principal features to be observed will greatly assist in the construction of them. In the construction of Bunkers the designs should be pleasingly varied and made all sorts of different shapes, sizes, and appearances. A Bunker should be perfectly visible and impressive looking; it should be well drained, constructed to remain up, and not fall in, and should not be liable to destruction by players and animals. A Bunker visible from one direction should be invisible from the opposite direction; in should be indistinguishable from a natural rise in the ground by having a gradual and sweet slope in the Fairways, thereby allowing the grass to be kept mown. The bottom of the face of a Bunker should be constructed with a considerable slope so that a ball will always roll to the middle and give the player a fair chance of getting out, but at the same time the top or face of the Bunker should be made sufficiently steep or in such a manner that it will stop a topped ball, and not allow the ball to run through it. A Bunker should be kept low if placed in the direct line of the hole, so as not to block the view of the Green. A Bunker should not be made too narrow or toc wide; if made too narrow, a player would have no chance of getting out, and if made too wide, a player would get out too easily; its construction should also prevent sand being blown out. Some Bunkers are made below the level of the ground entirely; some are partly below and partly above the ground, with a sloping and sand-splashed face or overhanging lip; but, no matter whether they be below or above ground, the preceding observations apply to each of them. With these general principles in view, the subject now forms itself into a question of how to proceed with the work. To save time and labour, and to give a resemblance to what it is intended to look like, a rough model of the Bunker and the lay of the land should be constructed out of modelling clay; a clear idea is then conveyed to the persons doing the work. The drainage should be made sound in the first instance, and the soil from the excavations made in the course of making depressions can be ultilised for making-up banks. Steep slopes and overhanging lips can be constructed by first building a wall of turf to the desired height, then cutting away the face to the desired angle. There are no hard and fast rules governing the size of Bunkers, as much depends on the lay of the land and its surroundings; but experience has shown that the height of the face of the Bunker is determined by its width, and the wider a Bunker is made the higher its face should be built. A measurement which is often adopted is that the height of its face should be equal to one-third of its width.

THE CONSTRUCTION OF TEES.

In the construction of Tees the principal points to be observed are—levels, drainage, and grasses. Very great attention should be given to these points, as in this case what is wanted is a firm level surface which will stand up to hard wear and tear. In marking-off the ground for the proposed Tee a little attention should be given to the line of direction which it is intended to play from, as the Tee can be constructed to face at right angles to the line of flight. Owing to the nature of the work, and with the object in view that of making a level surface, it is more satisfactory in the first instance to remove the top spit or surface soil from the whole area. When this is removed it affords a chance of putting the drainage into a satisfactory state and of getting on with the business of making levels. For the purpose of levelling it is necessary to use wooden pins, which are driven into the ground and which should be put in in such a manner that they can be easily removed for re-adjustment when the occasion arises, and when the work is finished; it is also essential to have a long levelling rule, 12 or 14 feet long, and a good spirit level to ensure true work. With the top spit removed, the subsoil has now to be levelled out, and to faciliate these operations it is necessary in the first instance to put in levelling pins to the desired height round the outer edge of the Tee; then, after that, pins should be put in all over the area at intermediate distances of 6 or 7 feet apart. Care should be taken to consolidate the work as it proceeds by treading in the soil firmly where it has been made up, as neglect of this part of the work will have a tendency to seriously affect the level surface when the work is completed. Where the soil is of a heavy nature the levelling pins should be kept 12 inches high from the level of the subsoil, and on the top of the subsoil put in a layer of clinkers 4 inches thick, which will be found to assist the drainage considerably.

The next work is to wheel on the surface soil, taking care to throw out the large stones and roots of weeds, and break down all the clods; put in the stable manure or peat moss, as the case may be, keeping it within two or three inches of the surface; tread down the surface as the work goes along until it becomes quite firm and to within half an inch from the top of the levelling pins. Next, with a view to the formation of a seed bed and a level surface, fill up the remaining half-inch to the top of the levelling pins with a finely riddled compost or finely riddled soil; then take the levelling rule and use it in the form of a straight edge, work it on edge from side to side, backwards and forwards, and just grazing the tops of the pins: by this operation the little hollows are filled up and the bumps shaved off, leaving a true and level surface. When this work is completed draw out the levelling pins and fill up the holes firmly with good riddled soil. This having been accomplished, give the ground a good roll and cross-roll until the surface becomes firm.

The Tee should now be left in this condition for a few weeks, as it will be sure to settle a little. When work is resumed, and before sowing the seed or laying the turf, examine the surface and correct any unevenness that may have occurred. If seed is to be sown, a dressing of artificial manure may be applied if desirable; rake the manure in, and sow the seed a day or two after on a raked surface, distributing the seed as evenly as posible; rake and cross-rake again, burying the seed to a depth of a quarter of an inch; after this, give the surface a light roll and leave it till the grass appears. The grasses to be sown on this occasion should consist of a combination of quick top and bottom growing grasses, relative to the nature of the soil.

As a guide for heavy soils the following combination may be useful:—

One part Crested dogstail.
One part Meadow foxtail.
One part Meadow fescue.
Half part Tall fescue.
Half part Perennial rye.

Where turf is to be laid care should be taken that all the turf is gauged to a uniform thickness and weeded before laying. Lay the turf on the top of the raked surface, keeping the joints closely together, and beat the turf lightly, but don't disturb the levels. Top-dress the whole area with a compost of finely riddled soil and sand of equal proportions, and in which has been mixed a pound or two of grass seed, brushing well into the joints and finishing off the operations by giving the Tee a light roll. It sometimes happens that Tees are constructed on sloping ground, which necessitates the making of sloping banks around the Tee; and during the course of their life the banks are subject to destruction from various causes and become unsightly and always a source of expense to maintain. This can be cured when the Tee is constructed by covering the slopes or banks with wire netting. Lay the netting flatly on the ground and pin it down to the ground with wire pins 7 or 8 inches long made from ordinary fencing wire and made in the form of hairpins. The grass will grow up beautifully through it and the netting is never detected; a scythe can be used without danger, and the banks or slopes are protected for all time. Where Tees are constructed on sloping ground a rough level may be taken first, and this can be accomplished by a very simple means—a peg, a length of cord, a stick marked with feet and inches, and a spirit level are all the implements that are required. At what is judged to be the highest points of the ground to be levelled, a peg with the cord firmly attached to it must be firmly driven in. The cord must then be extended over the whole area until the lowest point is found. This is done by sliding the loose end of the cord up and down the measured stick at various points until by means of the spirit level the difference between the highest and lowest points of the ground is dis-

covered; for example, if this measures 4 feet, it is necessary to establish a common level to throw 2 feet of the soil from the highest part of the land on to the lowest. Where the Tee is constructed on light, sandy soil, the putting in of a bed of clinkers may be dispensed with, provided the land drains are in good order. The soil being of a porous nature, it is quite obvious the necessity does not arise.

THE IMPORTANCE OF FEEDING TURF; THE VARIOUS FERTILISERS THAT CAN BE USEFULLY EMPLOYED FOR THIS PURPOSE AND THE MERIT ATTACHING TO EACH. THE DANGERS RESULTING FROM INDISCRIMINATE MANURING OF PUTTING GREENS.

The importance of feeding turf is to supply the grasses with plant food. Some soils in themselves are rich in this respect and may carry on without feeding for several years, but the time eventually arrives through the regular mowing of the grass that the soil becomes exhausted of certain ingredients; these ingredients are eaten up quicker than Nature can supply them, and the fertility of the soil deteriorates. Other soils, such as light, sandy soils, are poor in plant food to begin with, but, nevertheless, by systematic and judicious manuring these soils can be brought up to a high state of fertility. For the purpose in view there are three things necessary in order to maintain the fertility of the soil—nitrogen, phosphoric acid, and potash; and the various fertilisers that can be usefully employed for this purpose, and the merit attaching to each of them can best be described by having a knowledge of the various substances which supply them. There are various substances which supply nitrogen to the soil, but there are five of them which commend themselves for consideration; these are: Nitrate of soda, nitrate of lime, sulphate of ammonia, rape dust, and dried blood. In dealing with these substances the character of the soils and the atmospheric conditio ıs of a district are circumstances which have to be taken into consideration to determine which substances it is preferable to use, and in some cases it is also necessary to know what constitutes the difference between them; such as nitrate of soda and sulphate of ammonia. The difference between nitrate of soda and sulphate of ammonia is that the one is a nitrate and the other is not; which is a very important point to be observed. The question now arises: What is a nitrate? A nitrate is the nutritious form in which a plant takes in its nitrogen. Nitrate of soda or nitrate of lime are already nitrates, and results can be got from them within 48 hours of their application. Sulphate of ammonia has to be converted into a nitrate after it is put into the ground; the process takes about three weeks to accomplish, and will only do so provided there is a sufficiency of lime in the soil to allow the bacteria to bring about nitrification. Sulphate of ammonia decreases the amount of lime in the soil, but it has the property of encouraging grasses to grow and the ability

to destroy clover and weeds; it acts best in wet districts and can be mixed with other manures, but on no account must it be mixed with basic slag, otherwise the ammonia will be driven off. Nitrate of soda and nitrate of lime are highly soluble manures and quick in their action; they are very good on heavy soils and in dry districts and where it is known there is a deficiency of lime in the soil; they are best applied as a separate dressing and when once the grass has started to grow, the phosphatic and potash manures being put on previously.

Rape dust is slow in its action, but good on all soils and for young grass; it is often employed on soils which are subject to wireworm; the insect is believed to eat the rape in preference to the plants.

Dried blood is slow in its action and good on light, sandy soils.

PHOSPHATIC MANURES.

The following substances supply phosphoric acid to the soil: All forms of bones, mineral superphosphate, guano, and basic slag. The phosphatic manures manufactured from bones in the most of cases contain a little nitrogen. Bones in themselves, such as quarter-inch bones and bone meal, are slow in their action and take five or six years to give up all their phosphoric acid. Bones are treated in various ways to bring them into a more active condition, steamed bone flour being a case in point; but when treated by steam they lose a percentage of their nitrogen. Bone superphosphate is better known as dissolved bones, and is bones treated with sulphuric acid to bring them into a still more active condition, and gives up practically the whole of its phosphoric acid in the first year; this also contains a little nitrogen. All forms of bones have a tendency to create clover, and act best on light classes of soil. Mineral superphosphate is a mineral phosphate which is also treated with sulphuric acid to bring it into an active condition, but contains no nitrogen; it comes from various countries under various names, but probably the finest in this respect is the North African superphosphate, 124 mesh. Superphosphate is quick in its action and good on all classes of soil, but should never be used on soils that are inclined to be sour.

Peruvian guano is rich in both nitrogen and phosphoric acid; it also contains a small quantity of potash and a goodly percentage of lime; it is quick in its action and good on all soils.

Fish guano is produced from fish offal; it also contains nitrogen and potash, but is regarded as inferior to Peruvian. Basic slag is the residue in the process of smelting iron, and its composition is different from a mineral phosphate; it contains four parts of lime combined with one part of phosphoric acid, and besides that it contains a limited amount of free lime. It is very good for soils deficient in lime, and soils which are heavy. Soils which are sour, which are peaty, or rich in organic matter of any kind, are benefited by basic

slag. It is gradual in its action, and produces a heavy crop of clover. Put it anywhere on the Fairways, but never put it on Putting Greens.

POTASH MANURES.

Potash is a fertiliser which is seldom needed on heavy soils, but is frequently employed on peats and lighter soils. The heavier classes of soils as a rule contain plenty of potash, but in some cases it may not be in an available form that the plants can make use of and only awaiting for lime to unlock it. Although that may be the case, it is sometimes helpful to apply potash even to heavy soils, provided it is given in the correct form, as potash makes the plants hardier and makes them more liable to withstand disease.

There are many substances supply potash, but four of them commend themselves for the purpose in view: Sulphate of potash, muriate of potash, potash salts, kainit. Sulphate of potash and muriate of potash are occasionally used, but owing to their costliness in regard to the potash they contain they generally give way to kainit. Kainit acts very well on light soils and contains a goodly percentage of common salt, which assists greatly in retaining moisture, which is of great importance during dry weather. Potash salts does not contain such a high percentage of common salt as kainit, and is recommended for heavy soils should circumstances necessitate it.

THE DANGERS RESULTING FROM THE INDISCRIMINATE MANURING OF PUTTING GREENS.

The dangers resulting from the indiscriminate manuring of Putting Greens are—Creating an excess of clover by the excessive use of phosphatic manures; creating acidity of the soil by the improper use of superphosphate; the impoverishment of the soil by nitrate of soda or sulphate of ammonia being used by themselves without the addition of having previously applied phosphatic and potash manures to balance it. To avoid the dangers of indiscriminate manuring it is not only necessary to know the manures to apply, but what quantities to apply, and when to apply them. Great care should always be exercised in the mixing of manures that one form of manure does not destroy the properties of another. They must be as evenly distributed as possible and in as fine a condition as possible. Soluble manures like nitrate of soda are only used as top-dressings when once the grass has started to grow; otherwise there is the danger they would be washed down into the subsoil beyond the reach of the grasses and be lost.

LIME.

While lime cannot be classed as a manure, its importance in its relation to the soil is worthy of attention, and if properly used it gives beneficial results, which cannot be ignored. Whilst it is the case that phosphatic manures contain lime. it is there principally in the form

of a plant food; but sometimes cases may arise where an application of lime by itself is required to suit the particular case in question.

There are several purposes which lime serves; it neutralises acids and sweetens up sour soil; it is beneficial on heavy clay soils and peaty soils by breaking up the organic matter and releasing nitrogen and potash, which combine and form a nitrate of potash; it has a mechanical action in assisting to make clay lands more porous and friable.

To obtain good results and to avoid disastrous results from lime, the class of soil and the class of lime are circumstances which must be taken into consideration. There are certain indications which denote whether a soil is in need of lime or not, such as the presence of sorrel and where the ground has become sour; but where dubiety exists as to whether it is in need of lime or not a simple test of the soil is the best way to settle the matter. Take a sample of the soil and put it into a jelly jar; buy some hydrochorlic acid, mix 1 part of hydrochorlic acid to 3 parts of water, pour this over the soil and put your ear to the jar and listen; if you hear a fizzing noise, there is plenty of lime in the soil; if you don't hear the fizzing noise, that is an indication you do require lime There are two kinds of lime which are used for the purpose of liming, and it is very important to note the difference between them; the one is a carbonate of lime known as ground limestone, and the other is quick lime or lime shell; the difference between them is that the ground limestone retains its carbonic acid gas and is very slow in its action, while the quick lime, through the process it undergoes of burning, has the carbonic acid gas driven off and brought into quick action.

The carbonate of lime is principally used for light, sandy soils, and the quick lime is used for heavy clay soils and peaty soils. On no account should quick lime be used on sandy soils, or else the consequences will be disastrous; the little organic matter which sandy soils contain and which ought to be conserved will be broken up and render the soil useless for its present purpose; it is therefore very important to remember when treating sandy soils to use carbonate of lime. When treating heavy clay soils the reverse is the case from sandy soils; use quick-lime, as the organic matter here wants breaking up, nitrogen and soluble potash are released and add to the fertility of the soil, acids are neutralised, and sour soils become sweetened. The lime shell should be put on the Green in the form of a powder at the back end of the year. The shell is reduced to a powder by the application of water, 6 cwts. of water being the amount usually required to reduce 1 ton of shell, or the shell can be bought ready ground for the purpose. The amount required to treat a Green 20 by 20 yards would be $1\frac{1}{4}$ cwts., which would last for 5 or 6 years, but the best results are obtained by an application of $\frac{1}{4}$ cwt. (28 lbs.) every year. Better results are obtained by putting it on in small quantities.

R. HOOD.

Construction of Golf Greens.

By A. W. KIRKPATRICK.

ONE of the most important things in the construction of a Golf Green is to see that the drainage is quite satisfactory. However well the subsequent work may be carried out, the final result will not be satisfactory if this important work is omitted or improperly done.

Should the site of the Green be on a heavy soil or clay, the drainage must be most thoroughly done, as in this class of soil it is essential that all superabundant water should be quickly got rid of, or the Green will be soft and spongy during wet weather, and unfit for play during the winter months.

If the Green lies on the side of a slope the most effective drain is a horseshoe catch drain, laid say nine feet from the edge of the Green in horseshoe form, the outlet ends coming well down below the approach of the Green.

For an ordinary Green on fairly level ground the fish-bone drainage is generally effective, if properly laid; 3in. pipes are large enough for the lateral drains, and 4in. or 4½in. for the mains, placed 1ft. to 15in. deep, care being taken to fill up the trench with porous material such as clinkers, ashes, or old mortar refuse to within 4in. to 6in. of the top.

On light or sandy soils the drainage is not such an important matter, but even in this case any danger of standing water must be guarded against by proper drainage; in the case of the drains, they need not be so close together as on heavy soils.

Adequate drainage will tend to eliminate any sourness of the soil through water stagnation, often the cause of moss and other undesirable herbages.

The top soil should be dug out to the depth of 9in. to 1ft., and placed away from the Green, as this contains humus, which would take years to accumulate in fresh surface soil, and in some cases valuable organic manures. The existing subsoil should be well dug over, and where possible ploughed. Should the soil be of a very stony nature, and the Green is to be built up to any height over one foot, it would not be advisable to dig this up, as it will maintain a firm bottom, also perfect drainage, and in some cases it may be the natural drainage of the surrounding ground. Pegs may be driven in at desired levels as this will help to ensure an even surface in the course of construction.

The formation of Greens under varying conditions will open up a wide field of study, and the formation of each Green must needs vary according to existing circumstances in each individual case. Careful study of the soil must be carried out to ensure that no one mineral is in predominance, such as sulphate of iron, etc., and great care must be made to ensure that the soil is not of a super-acid nature or contains any malignant fungus. In the course of construction even compression of the soil is essential; this can be carried out by continual treading in preference to rolling.

Well-rotted stable manure should be placed on the surface of the rough formation at least 4in. to 6in. deep; it should not be dug in as this only encourages rough-growing grasses and weed seeds; nearer the surface the nitrogenous gases reach only the shallow-rooted grasses and greatly help to maintain them.

The higher parts of the Green will need a more generous treatment in the way of organic manures to, in some measure, counteract the tendency for any surface dressings of the higher parts to wash down to the lower levels, to the impoverishment of one at the benefit of the other.

On the top of the manure 3in. to 4in. of sifted soil will be needed. The first existing top soil, should it be comparatively free from weed seeds or other undesirable grass seeds, would be entirely suitable for this work.

In the case of very wet or heavy soils one-fourth sand may be added, as this will help to maintain a dry and even surface, and with a light or sandy soil a heavier soil would be needed to comply with the opposite conditions or nature of the soil. I have repeatedly found that on heavy or clay soils a light dressing of sifted breeze helps to a certain extent to eliminate worm casts, but it must be recognised that this is not an infallible cure for worm casts in any respect whatsoever.

From the end of March to the end of April, or, alternatively, from the end of August to the end of September, are the best periods for the sowing of the seed. Providing the weather is calm and the top of the soil is comparatively dry, the seed may be sown either broadcast or by a machine supplied for this purpose, as this procedure ensures an even distribution essential to all seed sowing. Sow at the rate of 1½ to 2½ ozs. per square yard, and even 3 ozs. under exceptional circumstances where a very quick return is desirable. It should be recognised that the more seed sown, a more even surface of grass will be the result, as spring-sown grass will in all probability be required to withstand a dry summer, or snow and frost will greatly hinder a weak bed of grass sown in the autumn. In the procuring of grass seed it is preferable to use only seed procured from a well-

known seed merchant, as inferior grass seed or seed unsuitable to the soil will only give unsatisfactory results, and in some cases is the forerunner of weeds.

Of course it is sometimes desirable to resort to turf, but it generally happens that the best of turf looks better the first year than ever it does in subsequent ones, generally getting worse each year, particularly if the turf is imported from a distance; and a seeded Green will, on the contrary, improve from year to year, constantly getting better as the time goes on. Once the seed is established it should be mown moderately short with a sharp machine or scythe when it attains the height of 3in. to 6in., and all weeds should be removed by hand before the Green is put into play.

If the Green is rolled with a light wooden roller while the grass is young, this will maintain an even surface, also greatly helps the growth of the grass.

After cutting the grass, the cuttings may be left on, as this affords sustenance to the grass by producing humus (decayed vegetable matter), much needed to the growth of the grass; also helps to ensure an even surface to a perfect Green.

FERTILISERS AND MANURES.

Sulphate of Ammonia (Sulphate). A salt of sulphuric acid ammonia, a volatile alkali.

This form of manure will quickly induce rapid growth, but is quickly exhausted. Where tanks are used to water the Greens it will be best to mix this manure with water at least 24 hours before applying it to a Green. Mixed at the rate of 1oz. to every 2 gallons of water, and left in solution for 24 hours, the result will be much better than can be obtained from the same amount directly applied to the Green in powder form.

Nitrate of Soda (Nitrate). A salt of nitric acid soda alkali, carbonate of sodium.

It is very rapid in action; it also gives immediate results, but in the use on a Green it is undesirable owing to its tendency to encourage the coarse-growing grasses and clovers, also it quickly washes through any porous soil.

Ferreous Sulphate (Iron). Usually found in sufficient quantity on fertile soil; it will under continual use tend to destroy weeds, and will promote root action of the grass; used at the rate of 2ozs. to the gallon of water, and slightly sprayed on, it will effectually kill moss without injuring the grass.

Potash. A vegetable alkali in an impure state; or Ashes of Plant life.

MURIATE, pertaining to Salt.

It should be carefully used or omitted on ground predisposed to the production of clover. It is little short of wonderful the way in which clover has come up after a single dressing of potash; a thing that would be highly beneficial to the farmer, but certainly to be avoided by the Greenkeeper. Any form of phosphatic manure should be used with care on a Golf Green, the result aimed at being so entirely different from the result required by the farmer. Bone dust or indeed any form of bone manure is best avoided on Greens, although very useful on Fairways, where clover is not so much to be objected to as on a Green.

LIME. A viscous substance or calcareous earth. CARBONATE, a salt formed by the union of carbonic acid.

One of the principal essentials of all plant life, many and varied are the manural values it affords to the grass in its various stages. It produces adequate volatilisation, sweetens sour land, retains moisture on sandy soils in preference, and reduces heavy soils to a more friable condition; also it hastens the process of nitrification or fermentation of bacterial life. Nitrogenous manures will be slower in action if there is insufficient time to release the latent nitrogen; it will also tend to neutralise a soil of a super-acid nature.

HORSE MANURE, DECAYED VEGETABLE MATTER, or Humus. Being of an highly nitrogenous nature, it should be applied only under very favourable conditions as top dressing for a Green. A certain amount of humus is conveyed to the soil by this means, but most of its valuable properties are lost through extreme volatilisation, and no quick result can be expected from this means of top dressing.

In the use of all fertilisers care and discretion must be carried out, and the chief point to be studied is the natural characteristics of the soil on which the manure is needed.

Invariably soils contain one acid in abundance; so it would be detrimental to the grass to apply that same acid on that soil; the one aim would be to neutralise it, not make it more profilic.

Over-indulgence in the use of any one manure, such as sulphate of ammonia or iron, etc., will produce only weeds, or a few undesirable grasses, as such grasses as the poa or fescue family can only assimilate a certain amount of nitrogen at any one time. A too liberal dressing will only cause deterioration to set in, and weeds would grow prolifically, as weeds such as the dandelion, etc., can assimilate treble the nitrogen than that of the grass consumption.

It should be recognised that nearly all fertilisers are procured from acids in their crude form, and the predominant

characteristic that prevails among all nitrogenous manures is their ability to produce a very rapid growth to the grass; but rarely can it retain this action for any long period. Clover also will assimilate a great amount of nitrogen, and retain it. Through injudicious use of a manure, clover would contaminate the soil in this respect, and would take years to eliminate by top dressings.

An erroneous idea is often prevalent that the more chemical manure used at one time will give better results; but the rule, "Little and often," should be recognised in the application of all fertilisers. On the other hand perfect turf cannot be maintained unless food suitable to the soil is applied at regular intervals, and so keep the turf in a position to please the eye of even the most critical turf expert.

CONSTRUCTION OF BUNKERS.

In the construction of Bunkers adequate drainage must be made to ensure a dry Bunker at all times, as a wet Bunker is a source of annoyance to most golfers.

There are no set rules in regard to the design of Bunkers, but the round or oval generally gives the best results both in play and appearance.

In constructing a Bunker on the downward slope, dig out the soil to the desired depth, and place at the face on top of the natural ground to form a semi-parapet, care also being taken to ensure that the face is parallel with the Green; in the case of an upward rise, vice versa would give the same result.

If the Bunker is constructed on loose, stony ground it will be found profitable to line the Bunker with clay or heavy soil 3 to 4 inches deep and well hardened with a rammer, as this will be a safeguard against stones coming in contact with the sand, and so save considerable amount of damage to clubs and machines. Wood-faced Bunkers (now obsolete) should never be made; not only is it unsightly but a very dangerous practice to maintain in regard to a ball played at a short distance on coming in contact with the wood.

In the course of constructing Bunkers in their intended positions various controversy will ensure as to where they should be placed. It will be found (on some courses) that some of the Bunkers through the Fairway are placed to penalise the scratch player in preference, unknowingly, but for this reason. Taking into consideration the longer flight of the modern ball, and the Bunkers made years ago, it will be recognised that some of the Bunkers were placed to penalise a misplayed second shot; they have never been altered, and now the modern golfer finds himself open to be penalised from a perfectly played drive.

I have found that on a Course where sand is at a premium the Bunkers may be turfed and left to grow to a reasonable height. This in most cases forms a formidable hazard, as an alternative to a sand Bunker.

The planting of rough grasses on the top of a Bunker is not, in my opinion, exactly a sporting proposition for a golfer to contend with. Should he, through a misplayed shot, find himself in a nearly unplayable position in a Bunker, it is hardly fair for him to play a perfect shot out, only to find his ball in an equally unplayable position just out of the Bunker, through the injudicious use of rough grasses.

Should the inside face of the Bunker be seeded, it is advisable to use only strong and vigorous-growing grasses. Rye grass lolium perenne would be entirely suitable for this work, as the wear and tear will often cause the Bunker to be made larger than first intended; more so on sandy soils this will be noticed.

Should the Bunker be constructed on very wet soils the following plan may be adopted:—Leave the site much the same as it is and procure ample soil to make a rise round the existing site to the desired effect. On placing the sand in the Bunker a slight slope to the back would effect a natural drainage, and drain pipes laid from the inside edge of the Bunker to the outside edge of the rise would release any stagnant water that may accumulate through incessant rainfall.

CONSTRUCTION OF TEES.

In the construction of Tees much the same process can be carried out in regard to building and manuring as in the formation of a Green. On constructing a Tee it should be built well off the ground level, with a slight rise towards the Green, say 1 in 22 will generally give the necessary rise.

Should it be built on wet or heavy soils it must be recognised that good drainage is essential, as nothing deteriorates a Tee quicker than inferior drainage, as during the course of a year a Tee gets more wear than any other part of a Golf Course in proportion to its size. The soil must be well compressed during construction, and it has been found very favourable to build in layers 2 to 3 inches thick, as this will ensure adequate soil compression. The sides should slope well away from the upper edge of the Tee; the higher the Tee is constructed, so should the sides slope accordingly, and it will be found advisable to have the extreme corners slightly higher, as the corners generally have a tendency to sink.

In making Tees at short holes, owing to continual iron club usage they will deteriorate quicker than elsewhere, but if the

Tees are made larger they can be used for a longer period, and so save a certain amount of deterioration.

Tees that are made in step-formation parallel with the hole often get more wear than actual golf when the back Tee is in play; but if they are constructed across the line of the hole they prove a favourable means of teeing ground.

In constructing a Tee on the downward slope of a bank the soil of the banks of the Tees must be well compressed, or during wet weather the Tee will have a tendency to become very uneven. Should the soil be of a very stony nature, stakes 4 to 6 inches broad, driven well in the face of the Tee, will allay any tendency the Tee may have to slide forward. It should be recognised that the more manure placed on top of the rough formation, the quicker will be the recuperation on the Tee being left out of play. A primary essential in the construction of Tees.

Only strong and vigorous-growing grasses should be used in the seeding, sowed at the rate of 1½ to 2½ ozs. per square yard, also seeds of grass that will recuperate or accumulate very speedily. Grass seed that was once intended for the sowing of a Green will never give satisfactory results on a Tee, and neither is it profitable to use such seed in any form.

In the matter of turfing Tees one cannot be too antagonistic against its use. Should the turf be procured from a disused pathway, and fairly free from weeds, it will be found that only the stronger and quick-growing grasses prevail, and favourable results will follow from turf used in this respect; also recuperation will be speedy on the Tee being left out of play for a time.

A. W. KIRKPATRICK, Greenkeeper.

Soil Acidity :

IN RELATION TO THE GROWTH OF FINER GRASSES AND WEED CONTROL.

EDITED by NORMAN HACKETT.

This article is composed solely of excerpts from articles by Dr. R. A. Oakley, Chairman of the Green Committee of the United States Golf Association, and published in their Bulletin.

THOSE who use the term " acid reacting fertiliser " really mean a fertiliser that, when applied to soil upon which plants are growing or are to be grown, will have a tendency to make the soil acid. By the same conditions, an alkaline re-acting fertiliser is one that, when applied to soil upon which plants are growing or are to be grown, will have a tendency to make the soil alkaline. Ammonium sulphate is a common example of the former, while sodium nitrate is a good example of the latter. In the test-tube, ammonium sulphate is not inclined to re-act acid; on the contrary, its reaction is towards alkalinity; but when added to the soil, plants avail themselves readily of the ammonium part of the fertiliser and leave the sulphur part, or at least most of it, unused. It is this part that tends to make the soil acid. In the case of sodium nitrate, when this substance is used as a fertiliser, plants use the nitrogen part and leave the sodium in the soil, which tends to make the soil alkaline. This is a crude and very homely explanation, but it is hoped that it will make the case clear.

It is quite an easy matter to make the soil of a Putting Green alkaline. Lime in any common form will do it in a relatively short time, but it is not nearly so easy to make alkaline or even neutral soils acid. It takes numerous and frequent applications of ammonium sulphate, for example, to offset the effect of a little lime in the soil.

Farmers and other plant-culturists very generally have the notion that acid soils (" sour soils " as they call them) constitute one of the greatest drawbacks to crop plant production. The following is typical of a very large number of enquiries which reach the American Green System: " The turf on our Greens is poor. We think the soil must be sour." It seems to be true that many of our important crop plants thrive better on soils that are neutral or slightly alkaline than they do on acid soils; but it is not correct to generalise from this that all plants prefer soils that are non-acid. As for our cultivated turf grasses, notwithstanding the many years they have been grown and studied it is regrettable, but

true, that their soil relations so far as acidity is concerned have in no case been critically determined. It appears to be true, however, that at least the bents and fescues—that is, the ones that we use in making Putting Greens—are so constituted as to thrive vigorously on acid soils.

Our friend the Greenkeeper then wishes to know how he can test his soil so that he may see for himself just how he is progressing in the matter of getting it acid. Technically the test is one which measures the p^H or hydrogen-ion concentration of the soil. But all those making it need to know or do about this technical feature is to regard p^H, or hydrogen-ion concentration, merely as marked on a scale. When a Putting Green soil shows 6.9 p^H by this test it is not sufficiently acid to keep clover, crab grass, goose grass, chickweed, or other weeds out of bent greens. It must get to about 4.5 p^H before results in this direction are reasonably to be expected.

For our purpose we may assume that it is the sulphate part of the ammonium sulphate and the phosphate part of the ammonium phosphates that makes soils acid; and we must bear in mind that we must use these fertilisers more or less continuously if we are to keep soils acid once they get into this condition. Soils seem to have a tendency to go back to their original condition when fertiliser treatment is discontinued. Our problem in this regard is how to get soils acid quickly without injuring the turf growing upon them or impairing their value for turf production. In the natural course of events, our fertiliser treatment, if we use ammonium sulphate, or ammonium phosphate in conjunction with compost, will keep soils at about the proper acidity.

But our good friend the Greenkeeper says, "I have used ammonium sulphate for some time and still I have white clover and other weeds in my Greens." Very well, but when we examine his soils we find them to be neutral or even slightly alkaline, regardless of the fact that he has used ammonium sulphate liberally. Probably at some time he has used lime on his Greens, or nitrate of soda, or both.

If you are still troubled with white clover and crab grass on your Greens after liberal use of ammonium sulphate or ammonium phosphate, do not think them ineffective in controlling these weeds. Your trouble is probably due to the fact that your soil was high in its lime content when you started. Possibly, also, you have used alkaline-reacting fertilisers in conjunction with ammonium sulphate or ammonium phosphate. The thing to do is to continue with these fertilisers in the way it has been found best to use them. Desired results are sure to follow.

Are we in this country on the eve of an almost entire change of opinion and practice in regard to the production and maintenance of the finest turf?

One of the advantages of the chemist and scientist over the theologian is that the former are able to prove or disprove their theories.

Within a comparatively short time their fellow scientists are able to confirm or refute their hypotheses; it may be months or years, but the truth is finally established.

Our American cousins have demonstrated that in the game of golf itself they have almost, if not quite, outstripped us. The dominant note in everything they undertake is thoroughness—thoroughness based on the elimination of every factor that can be deemed to be either casual or chance.

What they are able to tell us as a result of six years' continuous and assiduous investigation of the problems of turf culture must command therefore our unbiased respect and deepest attention.

" Tempora mutantur, nos et mutamur in illis "—applies with even more force to the problems of science than to men and manners.

I think it may be said, without fear of contradiction, that up to this very day all our leading home experts on turf culture have emphasised the point that a soil must at least be neutral to produce good putting turf. Peruse any of the standard books on this subject and one finds stressed on nearly every other page the need for lime. Lime to correct the acidity of the soil; lime as a factor in the complex process of making nitrogen available for plant growth, e.g., combining with the fertiliser sulphate of ammonia, and converting it into carbonate of ammonia—the first stage of the process; the nitrogen in this form is then taken in hand by the two groups of bacteria in the soil and oxidised into available form for absorption by the grass roots; and to complete the circle of its benefaction—these groups of bacteria can only function where lime has been used, to correct and neutralise acidity of the soil.

Though lime is not, and has never been, considered a fertiliser in itself—since it does not contain nitrogen—nevertheless, it has always been recognised as a necessary corollary for fertilisation.

This theory holds the field to-day in this country.

In November, 1920, the United States Golf Association appointed a Scientific Green Committee, with Doctors Piper and Oakley at its head—two of the foremost agrostologists in America; a turf experimental nursery was founded at Arlington, near Washington, and during the last six years both a trained laboratory and ground staff have been engaged continuously on the problems associated with fine turf culture and greenkeeping problems generally.

At this point I should like to introduce verbatim the opening lines of a paper read by Dr. Oakley at the Annual Meeting of United States Golf Association, Green Section, in January, 1925.

" Why do we fertilise Putting Greens? Broadly speaking, we do so under normal conditions to produce a vigorous growth of grass; under certain abnormal conditions to help grass recover from attacks of diseases and insect pests; and in general we fertilise turf to improve its quality. Let us understand clearly that the fertilising of a Putting Green and the fertilising of a hayfield are quite different propositions. In fertilising meadows, a large growth of hay plants is

what is sought; in the case of Putting Greens it is quality of turf, which involves, in addition to vigour of growth and texture, freedom from weeds. It is important that this difference be fully appreciated.

" For many years it has been known that the application of certain fertilisers or certain substances to the soil affects some plants favourably and others unfavourably when these plants are grown together in what we call mixtures or mixed cultures. The reasons for this are not at all clear, but the fact seems to be unmistakable. This has led investigators to endeavour to find fertilisers that will favour the plants they wish to favour and at the same time discourage the ones they wish discouraged.

" Twenty years ago the Rhode Island Experiment Station started a series of experiments to determine the difference in their effects on the bent and fescues of fertilisers having a tendency to produce an acid condition in the soil, and those having a tendency to produce an alkaline condition. The plots fertilised with acid-reacting fertilisers produced cleaner—that is, more nearly weed-free—turfs of the bents and of the fescues, than did those fertilised with alkaline-reacting fertilisers."

This was, then, their starting-off point at Arlington in 1920.

To sum up briefly from all the established results of the American experiments (and, moreover, subsequently put into practice on American Greens), several salient facts emerge:—

(1) That the finer grasses, i.e., the fescues and the bents, thrive best in acid soil.

(2) That the coarser grasses do not like an acid soil—that they flourish in a neutral or alkaline soil.

(3) That an acid soil is inimical to the growth of weeds.

The writer had the pleasure of a visit from Dr. Oakley last month. Het took him through all the field of their experiments; upwards of a hundred turf plots—fertilised year after year—each with its separate fertiliser or group of fertilisers—every plausible combination of fertilisers and treatment has had its continuous trial on a plot of turf; all the plots of turf were originally one common area. He showed numerous photographs of these plots, illustrating their present variance and condition—and in every case where an acid reacting fertiliser had been used solely (i.e., either sulphate of ammonia or phosphate of ammonia) the plots were composed of finer grasses and practically free from weeds.

The writer took Dr. Oakley to several links in Yorkshire. Two courses of moorland character had previously exercised the mind of the writer, owing to a certain seeming phenomenon; this was the curious fact that while the " pretties " and " rough " were composed almost entirely of beautiful red fescue and fine bent, with a notable absence of weeds, the Putting Greens were marked by the scarcity of these grasses and were made up chiefly of coarse grasses,

while clover and weeds were much in evidence. The writer on a former visit had tested the soil of the " pretties " and " greens " with blue litmus, and in every case had found the " pretties and " rough " acid—and the Greens to be neutral or akaline.

Dr. Oakley was very much interested. We found that the Greens had been treated from time to time with both lime and mixed fertilisers. Dr. Oakley declared that he could not wish for clearer evidence in support of their theory.

One would like to make one or two observations. Dr. Oakley is one of the most modest and unassuming of men; he constantly prefaced his remarks by saying that he did not wish to be or appear dogmatic, and on one occasion I found him almost apologising to a Greenkeeper because he found himself unable to accept certain of the said Greenkeeper's conclusions; but he did allow himself to say that the volume of evidence resulting from their co-ordinated experiments gave him in his own mind no option, but to accept their finding.

The next note is that in writing to one of our foremost seed-growing firms, two or three months ago, I was tempted incidentally to ask them if they did not think that an acid soil was the best for the finer grasses, which brought the reply that their experiments on these lines, extending over two years, " promised interesting revelations."

The outstanding results of these tests may be summarised as follows:—

The turf on the ammonium sulphate and the ammonium phosphate plots is now and has been since the first summer (1922), *practically weed-free* and of *good texture*, and otherwise of good quality.

The turf on the nitrate of soda, lime, and other alkaline-reacting fertiliser plots is now and has been since the first summer *quite weedy*, the important weeds being goose grass, crab grass, and white clover. Where lime alone was applied the turf has always been very poor and weedy. There is much *moss on the limed plots*—contrary to the popular notion that moss is an indication of an acid soil and that lime is a panacea for all acid soil troubles.

The turf on the soybean meal and cottonseed meal plots is very good, but somewhat weedy.

The addition of either acid phosphate or muriate of potash, or both, to plots treated also with ammonium sulphate or nitrate of soda did not give better turf than ammonium sulphate or nitrate of soda alone—in fact, not so good as ammonium sulphate alone—certainly not nearly so free from weeds. This indicates that in the case at least there is *enough available phosphorus and potassium in the soil* for the needs of the grass, a very significant point which should be borne in mind.

Another point worthy of mention is that *earthworms are not*

in evidence on the plots where acid-reacting fertilisers were applied, while they are present in considerable numbers on the plots treated with alkaline-reacting fertilisers.

At the end of the three-year period the soil of the plots to which ammonium sulphate was applied was appreciably more acid than at the beginning of the investigation, while the soil of the plots to which nitrate of soda and to which carbonate of lime were applied was appreciably more nearly alkaline than at the start. Generally speaking, the weediness of the plots in the series at this time is in direct relation to the alkalinity of the plots. In other words, the plots with the soil most highly acid are the ones freest from weeds.

Out of all the field of investigations and experience, including those at Arlington and elsewhere, has emerged what appears to be an extremely simple course of procedure for the fertilising of Greens. As the case stands to-day, it seems sure that the most satisfactory fertiliser treatment from the standpoint of turf and economy involves the combined use of *ammonium sulphate and suitable compost.*

Just a few reasons why it is thought that this combination is what should be used.

(1) Nitrogen is the outstanding fertiliser element for turf grasses. To be a good grass fertiliser a substance must be rich in nitrogen in a form available to the plant. Ammonium sulphate and ammonium phosphate are high in available nitrogen.

(2) It seems to be amply proved that the use of acid-reacting fertilisers goes far towards reducing the expense of weeding Greens. Ammonium sulphate and ammonium phosphate appear to be the best acid-reacting nitrogenous fertilisers now available, price and other factors considered. Not only are they capable of acidifying soils, but they promote the growth of grass which is satisfactory alike in vigour and texture.

(3) *The addition of phosphorus and potassium does not appear to be necessary at all other than when added by the application of compost.*

If nitrogen is the important fertiliser element to be supplied and the creation and maintainance of a rather highly acid condition in the soil is desirable in solving the weed problem, then it would appear that ammonium sulphate is the most effective and economical fertiliser to use.

As for the use of compost, in addition to its many other functions, some of which are well known, it supplies suitable organic matter, which is probably much needed and tends to counteract any evil effect the long-continued use of acid-reacting inorganic fertilisers may have on the soil.

For our immediate purpose a condensed table of this data is all that is necessary and is appended.

EFFECTS OF VARIOUS FERTILISERS ON PH VALUES AND PLANT GROWTH IN PLOTS OF RHODE ISLAND BENT AT ARLINGTON TURF GARDEN, VIRGINIA (NEAR WASHINGTON, D.C.)

Fertilizers employed	*PH value Nov. 1, 1925*	*Percentages of weeds in the turf*	*Kind of weeds*
Ammonium sulfate	3.7	12%	Ordinary crab grass. (Good stand of bent grass.)
Ammonium phosphate	4.6	15%	Ordinary crab grass. (Good stand of bent grass.)
Ammonium sulfate, bone meal, and muriate of potash; mixed	4.1	20%	Ordinary crab grass.
Ammonium sulfate and acid phosphate; mixed	3.7	20%	Ordinary crab grass. (Good stand of bent grass.)
Ammonium sulfate & bone meal; mixed	3.8	25%	Chiefly ordinary crab grass, with a trace of silver crab grass.
Cottonseed meal	4.8	30%	Chiefly ordinary crab grass, with silver crab grass and a little yarrow.
Check plot (no fertilisers used)	4.6	45%	31% ordinary crab grass; 9% spurry; 3% yarrow; 2% plaintain and others. (Thin and poor stand of bent.)
Bone meal	4.9	50%	22½% ordinary crab grass; 22½% yarrow; 2½% clover; 2½% plantain.
Soybean meal	4.6	60%	52% ordinary crab grass; 6% yarrow; 2% chickweed and others.
Sodium nitrate	6.3	80%	72% ordinary crab grass; 4% silver crabb grass; 4% yarrow.
Acid phosphate, sodium nitrate, and muriate of potash; mixed	5.8	80%	56% ordinary crab grass; 4% silver crab grass; 4% yarrow; 16% miscellaneous.
Manure	5.1	85%	51% ordinary crab grass; 9% yarrow; 4% plantain; 21% dock, dandelion, ranunculus, chickweed, white clover, sorrel, cinquefoil, and others.
Ground limestone	6.8	85%	68% ordinary crab grass; 4% yarrow; 4% clover; 9% dandelions, plantain, and others. (Weak stand of bent.)

From a study of this table it becomes quite evident that those fertilisers that tend to increase the acidity of the soil have benefited the bent grass and retarded the weed growth, while those fertilisers that tend to reduce the acidity encourage weed growth at the expense of the bent grass.

The plots receiving manure and lime are the weediest of the series, very little bent grass being left in either case. As might be expected, the weeds are more vigorous on the manured plots.

Except for the ammonium phosphate plots, the best grass and fewest weeds occur where the p^H or hydrogen-ion concentration is not more than 4.0. None of these plots have more than 10 to 15 per cent. of weeds. With a concentration of 5.0 to 4.0, the weed growth in general constitutes 40 to 60 per cent. of the covering, and with p^H 6.0 to 5.0 from 80 to 85 per cent.

There seems to be little relation between degree of acidity and kinds of weeds occurring in the various plots, although certain fertilisers do seem to favour certain weeds.

The plots were sown to Rhode Island bent in 1921 (N.B. Rhode Island bent corresponds to our bents, i.e., Agrostis Vugaris, Agrostis Stolonifera, and Agrostis Canina), and since that time each has been subjected to a definite fertiliser treatment. As the plots have never been weeded, they offer an excellent opportunity to observe the effect of each fertiliser treatment on p^H values (or hydrogen-ion concentration), and also the effect on plant growth.

The practical formula is as follows:—First select your soil for the compost; every Greenkeeper knows what is required; if it is too sandy, loam or clay must be added, and vice versa; the idea is a good friable soil as a base.

To every 80 parts of such soil add 20 parts well-rotted manure; this latter constitutes the humus ingredient as well as of course supplying nitrogen.

The above must be thoroughly mixed and sieved.

To every cubic yard or one ton of the above, mix in 15 lbs. of sulphate of ammonia.

The above is the quantity for a single application to 5.000 square feet of Green.

An application should be given *every month of the growing season*—that is monthly from April to August. The covering is so small that play is not in the least interfered with.

Many Greenkeepers in this country, compost in the late autumn; this time of the year is unquestionably wrong; the idea of composting during the growing period is that each blade of grass finding its base covered with a nurturing earth will respond by throwing out root shoots into it, resulting in a spread and density of the turf, and, of course, feeding the turf during the period of its growth.

The trouble is that from April to August is the very busiest time of the year for the Greenkeeper and his staff, and it takes all their time during this season of the year to cope with the growth of grass. It has been apparent to the writer for some time that where constructional and draining work on a course has reached finality, the Green Committees of clubs will have to consider steps whereby a full and adequate ground staff is provided during the spring and summer—and correspondingly cut down by about one-half from October to March. There are a few practical and sentimental reasons against such a policy, but where a club has a limited and budgeted amount of money available for the Green Committee's disposal, some such system is necessary if full economical value for the money is to be obtained.

Having established the desirability of an acid soil, some simple means of detecting acidity or alkalinity, and the degree of each became imperative.

Litmus has served the purpose up to very recently, but while litmus shows one of the other, it indicates no degree, its test is qualitative, but not quantitative.

However, the relatively recent discovery of the " dye indicator test," which depends upon changes of colour of dyes of known acidity range, is a wonderful evolutionary advance.

In this test the degree of soil acidity is shown by changes in colour and is indicated as p^H or hydrogen-ion concentration. An explanation of the chemistry of p^H is both too technical and unnecessary for any practical purpose. All that is required is to regard p^H as marks on a scale— with a little less than p^H 7.0 as the approximate neutral points.

Figures above 7.0 indicate degrees of alkalinity, while lower figures indicate degree of acidity.

The relation of p^H value to plant growth is rather interestingly brought out.

The " dye indicator test " for acidity has superseded litmus—because the latter only discriminates as between an acid and an alkali—whereas by the use of the former we can ascertain the *exact degree* of acidity of alkalinity. This is extremely important in testing soils, because we have learnt from the information contained in the previous articles that it is necessary to attain an acidity in soil *below* the degree p^H *4.5* before we can look for an *absence of clover and weeds*, and a turf composed of the *finer grasses.*

P.H. stands for the Power of Hydrogen Ion and modern chemistry has established that it is this factor alone in the chemistry molecular constitution of a substance that determines whether such a substance is an acid or an alkaline.

We can now entirely dismiss from our minds the chemistry of the subject and hold on to the simple idea that pH denotes marks in a scale— with a little less than pH 7.0 as the approximate *neutral* point; figures above 7.0 indicates degrees of alkalinity—while lower figures indicate degrees of acidity—a golfing analogy would be to call pH—*Player's Handicap*—with pH 7.0 as " scratch " (neutral)—a handicap of plus 4 would correspond to pH 3.0 or " very acid ": and here let me enter a caveat to our lay minds: Do not run away with the idea that what is deemed a " very acid " soil denotes an acidity that will burn or corrode; the term is entirely a comparative one—and the very strongest acid soil would not *taste* acid: in fact, the acid degree pH 4.5 corresponds exactly to the actual acidity of our perpiration on a hot day—while pH 1.77 is the actual normal degree of acidity of our human gastric juice—(unless we have been too long playing the 19th hole)—and it is neither necessary nor desirable to reach this latter extreme low point of acidity in the soils.

We are indebted to the British Drug Houses, Limited, as being the first firm to put on the British market dye indicators with apparatus for medicinal and agricultural purposes. The need for the latter was primarily prompted by the desirability of knowing how much lime to add to a soil in order to produce the heaviest crop of *hay* or other crops. In a hay crop the farmer desires as large a proportion as possible of the coarser grasses—cocksfoot, Timothy, rye grass, rough and smooth-stalked meadow grass, and the last possible proportion of fescues and bents; therefore his soil must be alkaline to encourage the coarser grasses at the expense of the finer ones. But the question of turf for our golf links is the exact converse proposition; we want only the finer grasses, and it is only in the medium of an acid soil that they complete more than favourably with the coarser grasses, to the latters' *gradual extinction;* and along with them also depart *their allies—clover and weeds.*

The B.D.H. Soil Testing Outfit is designed for actual use on the field or links, and consists essentially of a dropping bottle containing the B.D.H. soil indicator, and a specially designed porcelain boat which is divided by a partition into two unequal parts. One end of the boat is used for mixing the samples of soil with the indicator, and the smaller end for the reception of the coloured liquid which is drained off from the mixture. In addition, a small spatula is supplied for handling the soil and mixing with the indicator.

A red colour indicates a very acid soil.

An orange or yellow colour indicates an acid soil.

A green colour indicates a neutral soil.

A blue colour indicates an alkaline soil.

The precise changes of colour indicating p_H degrees are as follows:—

Full Red, p_H 4.0.
Orange Red, p_H 5.0.
Orange, p_H 5.5.
Yellow, p_H 6.0.
Greenish-yellow, p_H 6.5.
Green, p_H 7.0 (neutral).
Blue p_H 7.5.

All complete with porcelain boat, spatula and bottle of indicator, in cardboard box—price, 4s. 6d.; in stout leather-board box, price 6s. 6d. from the British Drug Houses, Limited, Graham Street, City Road, London, N.1.

The writer was recently, courteously afforded the opportunity of personally learning the opinion of no less a British authority than of Sir John Russell, O.B.E., D.Sc., F.R.S., Head of the Government Experimental Farm and Laboratories at Rothampstead, Herts, who not only signified his acceptance of the American principles, but was able definitely to subscribe to their validity by reason of the fact that their continuous experiments at Rothampstead with various fertilisers---extending over very many years---showed sulphate of ammonia used solely to be the one and only fertiliser that conduted to the growth of the finer grasses and correspondingly inhibited the coarser grasses, clover and weeds. The writer was privileged to see and examine all the varyingly fertilised plots of the original common pasture field at Rothampstead—and all the evidence was entirely confirmatory of the American findings. One might go further and say that it was identically the same; the only difference being that all the experiments at Rothampstead have always been conducted from the purely agricultural and farming point of view, and not approached from the fine turf standpoint; so that the salient facts as regard fine grass culture have been obtained—so to speak—from the inverse and discard of what is required for the most prolific agricultural return.

To return to the Soil Indicator Set. May one suggest to every *Greenkeeper of Golf Club Secretary* that he should immediately possess himself of one? Having done so, first of all test a few of your Greens; if lime or sea-sand has been used at any time during the last few years, or indeed any complete Green fertiliser, you will in all probability find your Greens to be " neutral," with varying quantities of clover and weeds—not to mention the coarser grasses, which to the unbotanical laymen will hardly appear as being " coarse," because when cut frequently—as on a Green—the young grass blades of the coarser grasses are far finer than when fully developed.

The mention of sea-sand raises a most important question as to whether its use is desirable. Hitherto we have all advocated and used it on Greens, with the idea that it " fined the turf," and made a porous soil, and since drainage is the first essential of Greenkeeping, this object was in itself good—but as sea-sand (as opposed to any inland sand), contains carbonate of lime up to as much as 30 per cent. in some cases, it would strongly emerge that its use must defeat the required condition of an acid soil. Dr. Oakley strongly deprecated it on that account. If one then points out that seaside turf on sea-sand is the best, the reply is that any lime in such a sandy subsoil has long since been dissolved away; the writer himself has proved this; and again, he was lately testing the Greens at a noted moorland course, which have lately developed considerable clover, and whose Greens have not had any lime applied, *as lime*, nor had any alkaline-reacting fertiliser been used, but considerable dressings of sea-sand. The Greens in question proved to be neutral (not acid)—and there appears to be no doubt that the presence of clover in this case is directly attributable to the carbonate in the sea-sand.

The writer's own practical experience then suggests to you to net select a portion of one of your " pretties," where you have either bent or fescue grass, or both predominating; you will here find the dye indicator change to red, denoting very acid soil. You may say in your mind, " But granted this soil is very acid, and bent and fescue are the only grasses, yet the turf is not *thick or dense* enough to make a Putting Green of it! " Quite true, my colleague, but having got the first essential of an acid soil, we must not forget that the fine grasses thereon need fertilising just as much, or nearly so, as the coarser ones, *only* we must give them their *nitrogen* in such a form as to conserve and expand them. This can only be done by supplying them with nitrogen in the form of *sulphate of ammonia*, and, moreover, it is also a *sine qua non* that this must be mixed with the *compost* and applied during the *growing* season, as per details set out in last month's article.

Readers who are more scientifically interested in the hydrogen-ion theory are recommended to procure " An Explanation of Hydrogen Ion Concentration; The Capillator Method: For the Determination of Acidity and Alkalinity in General Practice." By Henry A. Ellis, B.A., M.B., Ch.B. Price, 1s. Published by Messrs. H. K. Lewis and Co., Ltd., 136, Gower Street, London, W.C.1 ; and also to write the British Drug Houses Limited, for their catalogue and Hydrogen Ion Chart Sheet.

The Vital Importance of Top-Dressing

IN THE MAINTENANCE OF GREENS.

EDITED by NORMAN HACKETT.

This article chiefly embraces an address delivered by Mr. O. B. Fitts, of the Staff of the United States Golf Association, Scientific Green Committee, at their annual meeting, in January, 1926. The "Answers to Queries" are taken, by permission, from the printed "Bulletin" of the Committee.

EVERY Greenkeeper wants to keep his Greens in the best possible condition. Every active Green Committeeman appreciates the satisfaction which his club members derive from playing on turf of fine quality.

The results of the experimental work at the Arlington Turf Garden of the United Sates Golf Association, Green Section, have furnished convincing evidence of the fact that *top-dressing is indispensable* as an aid to the production of turf of good quality in the maintenance of bent Greens. The editor is informed that one has only to see the difference in the quality of turf garden and the areas of the same grass which were not top-dressed, to be thoroughly convinced of the importance of top-dresing. Many who visit the garden observe this difference and are convinced. And being so convinced that the turf on the areas which have been top-dressed is far superior to that on the areas not top-dressed, they almost invariably have certain questions which they desire answered. Usually, the first question is, "How do you top-dress?" And this is followed by the enquiries, "With what material do you top dress?" "How much top dressing do you put on at one application?" Now an answer to a question with the evidence before one is much more convincing than is a written answer. But, unfortunately, we in Great Britain are not able to inspect the Arlington Turf Plots, and therefore this article is prepared in order to set out the value of the American methods.

The function of top-dressing may be stated briefly as follows:—(1) It fills small depressions in the Green, thus making the surface smooth and true to putt on. With bent Greens especially, it keeps the creeping roots covered and prevents the development of the loose and fluffy growth above the soil surface which is always undesirable. (2) It provides and maintains a satisfactory mechanical condition of the soil which is essential to the continuous health and vigour of the turf, and to the maintenance of sufficient resiliency in the Green to hold a properly pitched shot, and yet retain that

moderate degree of firmness necessary to permit the putted ball to roll true. (3) It supplies plant food, other than that in the fertiliser, which is conducive to the growth of the best turf. (4) It helps in a way as yet unexplained. When such inert substances as ground cork, charcoal, or brush are scattered over the turf, the growth of grass is stimulated. One writer states that even common baling wire scattered on the turf in one instance noticeably stimulated the grass. The functioning factor in these cases is not known.

Special attention is drawn to the two prints of turves appearing on another page. In both figures is shown turf of the same strain of bent—given identical treatment, except that the turf seen in Fig. 1 was top-dressed each month during the growing season, and that in Fig. 2 had not been top-dressed at all during the season.

The materials used for top-dressing Putting Greens are numerous, and it is important to know which will best meet the requirements. A simple examination of the soil of the Green is sufficient to determine its texture. Then the texture of the top-dressing material best suited for use on the different types of soil may be determined as follows:—If the soil of the Green is heavy, with a tendency to become sticky and slippery when wet, and to bake as it dries out, the indications are that a material of light and porous texture should be used for top-dressing. If the soil is of a medium loam type, a type of soil which is highly satisfactory for Putting Greens, the material for top-dressing should be of similar texture. If the soil is sandy or a light porous type, the material for top-dressing should be comparable to a heavy loam. In other words, the material best suited for use on a Putting Green is one which contains sand, clay, and organic matter in such proportions as will, when in combination with the soil of the Green, provide the equivalent of a good garden soil.

Compost is probably the most popular material used for top-dressing Putting Greens, and where proper methods are employed it produces very satisfactory results. The term "compost" as here used in the case of materials for top-dressing Putting Greens is applied to a mixture of such substances as sand, clay or loam, and manure or some similar organic matter. The proportion of these substances in the mixture is the governing factor in providing the desired texture. This is a point that should be thoroughly understood and should be given full consideration when mixing compost for dressing Greens of different types of soil. If a compost of light and porous texture is desired, the sand content should predominate; that is, the more sand the mixture contains the lighter and more porous the texture will be. If a medium loam of friable texture is desired, equal parts of these substances may be used in the mixture.

It is doubtful whether it is advisable to use a compost for top-dressing for Putting Greens that contains more than one-third organic matter, and where pure stable-manure is used as the organic

content it should not exceed one-fourth of the mixture. The chief objections to a high percentage of manure in compost are its tendencies to attract earthworms and grubs, to over-stimulate the growth of the turf grasses, and thus to form a surface layer that is loose and spongy and has a tendency to shed water instead of absorb it. For these reasons it is not advisable to top-dress Putting Greens with manure alone.

Sand alone is probably more generally used for top-dressing Putting Greens than either clay or manure alone, as is indicated by the numerous enquiries regarding the advisability of its use for this purpose. Experience at the Arlington Turf Garden with *sand alone as a top-dressing has been very unsatisfactory*, while a compost of mixture containing as high as 60 per cent, sand has been used with satisfactory results on heavy clay soil.

It is a general belief that sand, when applied on heavy soils, will work down in the soil and break up surface cohesion and thus provide better drainage and permit better air circulation. This theory is supported by advocates of sanding Greens, who contend that an occasional dressing of sand is necessary to maintain the proper mechanical condition of the soil. If such an action really took place when sand was applied to heavy soils, wonders could be worked with sand as top-dressing for Putting Greens; but, unfortunately, the theory is wrong. *Sand does not penetrate soil.* This may be readily observed simply by examining the surface of the Green from time to time after a dressing of sand has been applied. The sand will be found to remain on the surface until it is washed off or otherwise removed or is covered with an application of some other material. By cutting cross-sections of a Green that has been sanded at intervals for several years, and has been dressed with other materials between the times when it was dressed with sand, the various applications of sand will be found to have formed distinct layers in the soil. These layers, which are sandwiched in with layers of the other materials used for top-dressing, show that sand does not penetrate the surface to which it is applied.

Since, therefore, sand does not penetrate the surface to which it is applied, it naturally does not change the mechanical condition of the soil of the body of the Green, but simply adds or provides a surface layer of coarse or sandy texture. This surface layer, especially when applied to Greens, of medium or clay loam soils, tends to form a hard macadam-like crust, which is decidedly detrimental to the health and vigour of the turf. The frequent waterings, the rolling with a Putting Green mower and other implements, and the constant trampling by the players and labourers after the sand has been applied, submit the Green to a process somewhat similar to that employed in making a macadam road, and, the effect is, to a certain degree, the same. This condition is injurious to the turf in two respects: First, the individual shoots of grass become surrounded with the sharp grains of sand, which

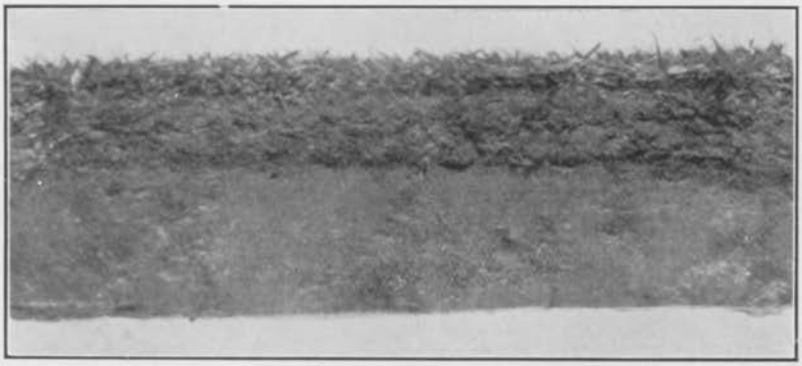

Fig. 1.—Cross-section of a piece of turf from a portion of a plot of Washington creeping bent, which has been top-dressed monthly during the season 1925. Note the firm, true surface presented.

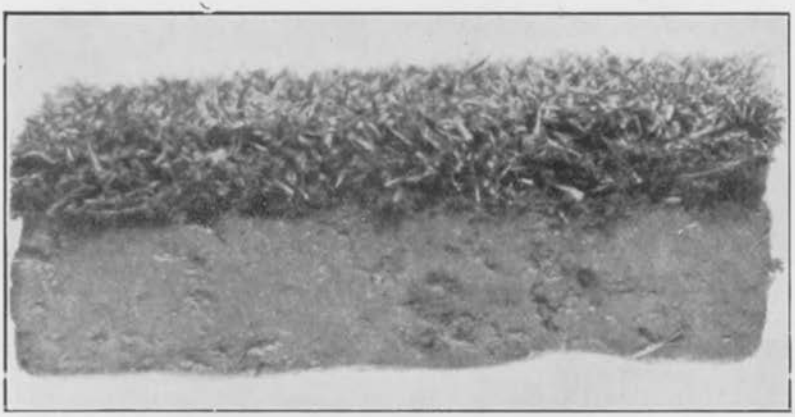

Fig. 2.—Cross-section of a piece of turf from another portion of the same plot which had not been top-dressed during the season. The turf is loose and fluffy, impossible to cut satisfactorily, and undesirable for putting purposes.

are crowded and jammed against them, bruising and injuring them. in many cases to the extent that the turf become noticeably weak and thin. Second, after the sand has formed the compact layer, as the players or workmen walk over the Green or the mower rolls over it, the grass which is left sticking up through the surface of the sandy layer is crushed against this hard grater-like surface, and as a result there is a continuous weakening of the turf, which will be the case as long as the layer of sand is not broken up and a more resilient surface is not provided.

Many Greenkeepers in the northern part of the United States believe it necessary to dress the Greens with sand in the fall to help carry the turf through the winter. It is very doubtful this is ever helpful to the turf, and in many cases, especially where the Greens are to be played on during the winter, it is harmful to the turf. The only logical reason for using sand as a top-dressing for Greens that are to be played during the winter is to provide a putting surface that is not too slippery and sticky for winter play. For this purpose a dressing of sand in the late fall is effective.

All the logical reasons for *top-dressing during the growing season* may be more satisfactory accomplished with a dressing of compost or a mixture of sand, clay, and manure in the proper proportions than with a dressing of any one of these substances alone. The dressing of compost is preferable, because it accomplishes the desired objects without danger or injury to the turf or playing conditions of the Green, whereas sand, clay, or manure alone may result in unsatisfactory conditions of the turf and of the Green as judged from a playing standpoint.

With regard to the method of applying top-dressing, the experimental work at Arlington Turf Garden, on a fairly heavy clay soil, has shown that the most satisfactory results were obtained there from *monthly applications, during the growing season*, of 1 cubic yard (one ton) of compost to 550 square yards of Green. The compost used in these experiments consisted of approximately equal parts of sand, loam, and organic matter, with which *10 to 25 pounds of ammonium sulphate* had been thoroughly mixed. The mixture containing 10 pounds of ammonium sulphate was employed during the hot weather, and the mixture containing the 25 pounds during the cooler weather of spring and fall, when the grass was not likely to be burned with a heavy application of this chemical. If desired, ammonium phosphate may be substituted for ammonium sulphate, and practically as good results obtained, as fertiliser experiments at Arlington Turf Garden have indicated.

Compost should always be brushed well down into the turf, and the Greens should be thoroughly watered after the compost is applied. There is still a tendency among Greenkeepers to top-dress too heavily and to leave the compost on top of the grass, instead of brushing it down into the turf. Fortunately this method is becoming less common, and it is hoped that it will soon be abandoned entirely in

favour of the light and frequent applications. These almost invariably produce better results; and, when applied in the manner above suggested, the compost does not interfere with play, care being taken, of course, to brush it down well into the turf. Heavy applications, on the other hand, interfere with play for a considerable length of time.

Occasional light dressings of sand probably would not be harmful to turf provided dressings of compost were applied between times.

However, even in such cases, care should be taken not to dress heavily, as the general tendency is to use too much sand when it is applied alone.

An analysis of the present information in connection with these various top-dressing materials and the various methods of applying them leads to the conclusion that the light and frequent applications of compost and ammonium sulphate, or ammonium phosphate, are the most satisfactory.

BENT.

" Bent is not a hazard R. and A."; note under definition 6 of the rules of golf. As not one golfer in a thousand knows what is referred to as " bent," it would seem as if it should make very little difference whether or not bent be a hazard or an assurance of safety. But, of course, every golfer should know the rules even if he have trouble in defining what they mean; he certainly needs education as regards " bent."

" Bent " is an old Anglo-Saxon word, according to the dictionaries akin to the German word " binse," a rush. Originally the word " bent " seems to have been applied mainly to stiff-leaved grasses, but by extension has come to be attached to a diverse medley of species, and even to sedges and rushes. Botanists think of it as applying mainly to the genus Agrostis—which includes Agrostis Vulgaris, Agrostis Canina (velvet bent)—the American Rhode Island bent and many similar others. It is these bents that produce both good Fairways and the best Putting Greens, but the word is also used for grasses of the genera Nardus, Elymus, Ammophila, Andropogon, Calamagrostis, and others. Of course, only a botanist knows all these grasses, but among them are some coarse and 8 feet tall, and others fine and delicate and only a few inches high. In short, the word " bent " is now widely inclusive of very different grasses.

There are, however, other meanings attached to " bent," namely, " a place covered with grass; a field; unenclosed pasture land; a heath." There are also the adjective " benty " as used for a place covered with bent, and the noun " bentiness," signifying the state of being benty. Finally, " benting " denotes the act of collecting bent or bent stalks. These words are manifestly derived from the grass or grasses called " bent."

Which is the grass that gave origin to the decision that " bent is not hazard "—whether the word refers to the grass itself or the area covered with the grass?

The obnoxious thing they mainly refer to as bent is a coarse grass of the sand dunes, Ammophila arenia, or Arundo arenaria. In the United States a very similar species is A. briligulata. The European grass is also called " marram," " sea reed," " sea mat," and " spires." The American species is commonly called " beach grass." Both are closely similar, tall, coarse grasses that grow in the loose sand. Both have been used to plant in sand dunes to keep the sand from drifting, and large areas of blowing sands have in this way been anchored and later planted to forest.

The general tendency at present among botanists is to restrict the name to grasses of the genus Agrostis and immediately related grasses.

ANSWERS TO QUERIES.

Query.—Weeds encouraged by Lime: In preparing top-soil for our new Greens, would you advise the admixture of lime? (New York).

Answer.—In your locality the most serious weeds in Putting Greens are crab grass and white clover. These are encouragtd by the use of lime. In the eastern part of the United States we have never learned of a soil so acid that it will not produce good turf. We would not advise your using lime.

Query.—Controlling Poa annua. What is the best method of controlling Poa annua?

Answer.—The only certain way of getting rid of Poa annua in a Putting Green is to weed the plants out by hand in early spring, before they have had a chance to make seed. If you do not do this, it is sure to spread in your Greens and make trouble. One club reports that it has rid its Greens of Poa annua and kept them clean by the constant use of ammonium sulphate. We have not experimented with this, however, and therefore can only offer it to you as a suggestion.

Query.—Possible Superacidity of Soil for Bent Grass. Is there any danger of getting soil too acid for the growth of bent grass?

Answer.—We have never been able to get soil too acid for success in growing bent grass. Our most acid soils are about p_H 3.7 at the present time, and the bent is doing well in them.

Mr. Norman Hackett will be pleased to hear from any Greenkeeper on any point of interest or difficulty, either through " Golfing " or direct.

Fertility of the Soil.

Lecture given by Mr. R. Birch, of Messrs. James Carter and C., at the London Stone Hotel, Cannon Street, E.C.

I DO not mean to make my lecture one on geology, but to treat on the aspects of interest in the production and maintenance of a good grass sward, mainly the physical and chemical features on which the fertility of the soils depends.

It would seem very simple to determine the fertility of a soil by making a chemical analysis of it, but a chemical analysis is not a complete test, although helpful to a certain extent. The texture of a soil, its mechanical conditions, is an important factor in the growth of plants. It is sometimes argued that a chemical analysis is not of practical value as it does not indicate truly what food is immediately available for assimilation by the grasses. But we must take a broader view of the value of soil analysis; it determines the potential plant food, and a plan of treatment may be formulated for permanent improvement.

The origin of most soils is in different kinds of rock. By the action of the weather and other agencies the rock is disintegrated, it is gradually reduced to fine particles, and there is an accumulation of organic matter resulting from decaying vegetation. Frost, rain, and changes of temperature all help to break up the solid rock foundation. The surface being exposed, we get the transition from the more fertile top-spit to the subsoil. The earth's crust consists mainly of a few minerals, silica, iron, magnesia, lime, potash, and soda, with an admixture of organic matter, water, gases, and bacteria.

The constituents in varying quantities go to form soils of different character or texture.

On the texture of a soil depends the supply of water to the grass plants—its capacity for holding water.

Typical soils are sandy, calcareous, or lime soils, loams, clays, peat, and marsh. From a practical point of view the classification is most important.

Typical sandy soils are found in the lower levels of rivers passing to the sea, where an accumulation occurs on the coast. The open textures of the soil is due to the free percolation of water, which, by the action of carbonic acid, removes the soluble elements. Generally therefore sandy soils do not possess any percentage of lime, except when formed by the breaking down of shells. On the other hand, iron is present, while potash is lacking.

A sandy soil is a difficult proposition to the Greenkeeper. By

washing away of organic matter the soil is deficient in humus, lime, and other fertilising salts. On sandy wastes and commons, gorse will be seen, and as gorse does not like lime, its presence is an indication of the absence if lime. While the soil is so impoverished and its condition is not conducive to the growth of the finer desirable grasses, less fastidious plants are a source of anxiety and trouble. Weeds such as yarrow, owing to the ramification of its roots, will flourish at the expense of the fine grasses. For that reason, farmers will include a little yarrow and rib grass or plantain when sowing permanent pasture on dry, open and hilly land, when difficulty is experienced in getting a good plant of the better grasses.

To improve the fertility of sandy soil, humus or organic matter must be added. Not only does it furnish plant food directly, but it render the soil more retentive, and the grass does not suffer to the same extent in hot, dry weather. When mowing greens on light porous soil, it is advisable not to use the box, except, of course, when the weather is wet, as the grass mowings form a kind of mulch, help to conserve the moisture, and a certain amount of organic matter is returned to the soil.

Humus is added by dressing with suitable compost, which has been stacked for some time. I am afraid the importance of the compost heap is not recognised as it should be.

I have mentioned that lime is deficient in sandy soil, and as the production of a fine turf is impossible without lime in the soil, liberal dressings of lime are essential. The applications of lime must be frequent as the rain soon washes it away. But it must be added in the form of carbonate of lime, or pulverised chalk, as its action is slower and has not such a rapid disintegrating action on the organic matter.

Care must be taken in using artificial manures on light soils. Sulphate of ammonia is inclined to make a soil sour if applied frequently, while nitrate of soda is wasteful as it is washed away too quickly.

There is a transition from the sandy soils to loam, which generally is the type of soil most desirable and most fertile. The physical or mechanical condition makes the maintenance of a good turf less trying, the loams are more retentive, contains more humus, and lime is usually present in sufficient quantity.

Calcareous soils differ greatly according to the percentage of carbonate of lime present, and the texture varies.

Some calcareous soils are comparatively heavy, such as the marls, while on the other hand the soil is light and more friable. Some soils overlying chalk can hardly be described as calcareous, in many cases lime is entirely absent. Soils of this type may give a lot of trouble, when wet they become sticky and form a hard pan when the weather is dry, the aeration of the soil being restricted and the grass is arrested in growth.

To improve a calcareous soil it is apparent that humus must be added, and it benefits by prepared charcoal, which improves the texture, and, being a non-conductor of heat in hot weather, the soil does not cake. Nitrogenous manures are necessary in treating a calcareous soil.

The clay soil is recognised by its tenacious character; and it is the fineness of the particles which makes it so retentive and impedes percolation and aeration. Drainage is important in rendering a clay soil more friable.

Clay soils, owing to the fact of the difficulty of percolation of water are rich in mineral salts. Also the closeness of the soil reduces the aeration, and in consequence unoxidised iron compounds are present. In a measure the infertility of some clay soil is attributable to this.

Clay soils accumulate organic matter, but are generally deficient in lime. Lime on a clay soil is invaluable in improving the texture it makes it warmer and renders available for plant food, nitrogen and potash, while it acts on iron compounds.

Clay is plastic, when wet it can be moulded, the particles adhere closely together. When it is dry it become hard and shrinks. When saturated it become impermeable.

It may seem strange, but clay soils have a greater pore space than sandy soils. The particles of a clay soil are much finer and more numerous, and as the water forms a film round each particle, naturally a greater quantity of water is retained. If a little powdered clay is placed on some water it will remain suspended and make the water clouded for some time.

But if calcium chloride is introduced the water becomes clearer. This is caused by groups of the particles coming together. Lime when applied to a clay soil effects a change in the texture in the same way; it brings together the particles and so makes the soil more friable, air is admitted, it is not so retentive.

Basic slag, although it contains a good percentage of lime, is not advisable, as it promotes the growth of clover.

Charcoal is invaluable on a heavy soil.

Charcoal is, as you know, the residue, after removing the volatile constituents of animal and vegetable substances. It is produced from wood, bone, and coal, but it is wood and bone charcoal with which we are concerned.

Both wood and bone charcoal are very beneficial when applied to soil of a heavy or retentive nature. Being used as it is, as a filter, its properties are apparent, it serves as purifying absorbant, it neutralises the acidity of a soil, aerates the soil, and improves the texture, making it less retentive, and is not excessively wet during rainy weather; nor, on the other hand, does the treated soil consolidate and shrink in hot weather. A more desirable rooting medium is produced.

Wood charcoal has purely a mechanical action, it possesses no manurial properties. But bone charcoal contains a little phosphates, and the grass may benefit by this.

The charcoal is prepared in several grades for use in the treatment of soils in varying conditions.

No. 1 grade wood charcoal, not exceeding half or less than three-eighths of an inch, for very soft, wet, sticky soils.

No 2 grade wood charcoal, not exceeding three-eighths or less than a quarter of an inch, for soft, wet soils.

No. 3 grade wood or bone charcoal, not exceedinga quarter or less than an eighth of an inch, for medium soils and mossy turf.

No. 4 grade wood or bone charcoal, not exceeding an eighth of an inch, for light, stagnant soils, and mossy turf.

In applying the charcoal, say half to one pound is calculated to the square yard. The application should be made when the ground is wet, so that it is more easily absorbed. Then roll the turf to press in the charcoal. To facilitate the absorption of the charcoal, the dressing may be supplemented by some sifted sharp sand.

Breeze is also a good thing to use in improving and fining down a heavy soil. Light dressings should be made at intervals, using material which has been passed through a one-eighth inch sieve.

Surface tension of water has an important bearing on the condition of a soil. All liquids have a tendency for the surface to withdraw into the smallest area, in fact, sufficient to overcome gravity. To convey to you my meaning, if I were to take a tube with a fine bore and place it in a bowl of water, the water will rise in the tube above the surface of the water in the bowl. Yet if I placed a wider tube there would be practically no rise of water in the tube. The capillarity is diminshed. Now you will undrstand why it is that on a compact soil evaporation is so rapid; the soil is denser, the particles are arranged closely together, and the pores are narrower, so that the ascent of the water which tends to reduce the surface area is quicker. If you disturb the surface, break up continuity of the passages, capillarity in checked, the moisture is conserved to a certain extent, and the grass does not suffer in dry weather.

On an ill-drained retentive soil the roots of the grasses remain quite near the surface where the soil is aerated, and when a drought is experienced, naturally the grass, owing to the roots being so shallow, suffers more than does grass which has a deeper rooting hold.

In preparing the site of a Green which is to be sown, a fine-tilth yet firm seed bed is aimed at. The object in obtaining a fine firm surface is to ensure a passage of water from the lower soil to the top, and maintain the surface layer in a uniform state of moisture, which is most important to induce the germination of the seeds. When the seedlings are up, an effort must be made to conserve the

moisture by dressings of Compound Mulch, a fibrous preparation. This is particularly applicable in the case of Spring sowings, when a dry of very cold spell may be experienced.

In the treatment of Greens on soil of a heavy nature, the surface of which dries quickly, to open up the soil, to reduce evaporation, the most useful implement is Sarel's spiked roller. This automatically keeps the surface aerated, it is very beneficial on clay soils, which are apt to get too consolidated. There is no risk of over-rolling or doing harm to the Green by roling when too wet.

It is also invaluable to facilitate the absorption of dressings. In the case of a heavy soil to be dressed with charcoal, the Green should be first rolled with the spiked roller so that the charcoal works into the soil easier.

The spiked roller can be used with advantage on all soils. In the improvement of the texture of a light soil which necessitates frequent dressings of compost, the soil is more receptive.

Chalk or carbonate of lime is found in nearly all soils, excepting a few very open sands and peat soils of vegetable origin. Some soils which has been derived from the chalk formations have a big percentage of lime,but most cultivated loams have as little as one per cent. In clays and sands there is often only a trace.

Carbonate of lime is not a permanent substance in the soil, as it is always being removed by percolation of rain. The decay of plants or roots in the soil generates acids, and these act on the calcium carbonate.

With the destructive agencies it is remarkable that any calcium carbonate remains in the surface soil, but we must bear in mind that it is returned to the soil by the plants. The calcium salts are taken up by deep-rooting species from the subsoil, and become calcium carbonate when the plants decay.

Humus is of indefinite composition, but is formed by the decay of vegetation, which is brought about by bacterial action. It is always present in larger proportions in grass land than in cultivated arable land. When a soil becomes stagnant or water-logged so that no air can enter, the accumulation of humus reaches its maximum, and the soil gets sour. An important property of humus is that it acts as a weak cement and binds together the soil particles, so that it not only makes a sandy soil more compact, but by forming groups of the fine particles it makes a clay soil more open.

The decomposition of humus is slow in the case of peat and bog. As soon as the acidity is corrected by lime, the bacteria becomes active and decomposition of the organic matter is hastened. But too liberal applications of lime should not be made, repeated lighter applications are advisable, for lime used in excess may cause the too rapid liberation of the valuable nitrogen, and in consequence the soil may be impoverished.

Peat soils are formed by the accumulation of humus, and as it is so retentive, its saturated condition excludes the air, so that it becomes acid. Owing to the acidity of the soil the bacteria are inactive.

Invariably peat soils show a deficiency of potash and lime, and until this deficiency is remedied the soil is infertile and the grass makes a poor growth. Difficulty is also experienced in obtaining a firm surface.

Lime should be added to improve the texture, and dressing with charcoal is important.

To improve the fertility, applications of suitable fertilisers should be made, to compensate for the deficiency of the minerals.

Bacteria have the reputation of being the cause of sickness and disease of both human and plant life. Yet there are certain bacteria without which life would not exist. These minute microscopical organisms occur in all soils, no matter where, although not always active. To say that one hundred million bacteria are to be found in one gramme of soil sounds incredible, but it is not an exaggeration. They are present in greater numbers in fertile soils. In acid, humus, and heavy soils, they are fewer, for, although a certain degree of moisture is necessary for the increase of bacteria, a warm temperature and air is also required.

Much of the material of which soils consist is not essential to growth of plants, but serves as a rooting medium and conveyor of moisture. And most of the potential plant food is not available for the nutriment of plants but, by the action of bacteria the inert substances are rendered available. It is a continual process; in fact, the soil is really populated with these organisms, like colonies of workers liberating elements for use by the plants, so that fertilisers and manures which are applied may be utilised.

Carbon dioxide and humus are the product of bacterial action. The grass is supplied with carbon dioxide for its assimilation, while the mineral constituents of the soil are decomposed and inert food is made soluble. Carbon dioxide is also produced by the roots of the grass, but in negligible quantities, not sufficient to maintain a healthy growth.

You may wonder that there is any infertile soil. In all probability you have come across turf which, in spite of generous manuring does not seem to thrive, the grass seems to be struggling for existence. This condition is termed " sickness " of the soil. It may be attributable to injudicious manuring, quantities of raw fertilisers may have been used, but not in proper proportion. As an instance, too much lime will curtail the availability of potassium. There are other reasons, of course, which might be the cause of the indifferent growth of the grass. Yet if the mechanical and chemical conditions are

apparently satisfactory, soil sickness occurs, and it has been discovered that there are other organisms which kill off the useful bacteria. These organisms, called protozoa, are most destructive when the soil is wet.

An idea of the nature of soil and its chemical constituents can be obtained by careful observation of the species of grasses and other plants which occur naturally. These may be described as indication plants.

I think it would be of interest to mention a few notable examples, as they may be of some guidance in the treatment of soil.

On sandy soil Agrostis, smooth meadow grass, brome grass, and species of Aira are to be found; while on the coast the sand binding grasses, Psamma arenaria and Elymus, occur. The weeds to be found are yarrow and clover.

On heavy wet soils Poa trivialis, rye grass, meadow fescue,Timothy holcus (Yorkshire fog), Aira coespitosa. Prunella vulgaris, daisies, sorrel, plantain, and rushes are a sure sign of sour soil.

The species most prevalent on moor and heath are Nardus stricta, sheep's fescue, and Agrostis.

Some grasses, like Poa annua, may be described as vagabonds; they seem to be able to adopt themselves to almost any soil.

Not only will grasses occurring naturally give an idea of the nature of the soil, but certain species indicate the presence of chemical elements. For instance, Agrostis, dogstail, cocksfoot, smooth meadow grass, Poa trivialis, rye grass, and meadow fescue, indicates the presence of potash.

Psamma arenaria, Elymus and other coast grasses indicates the presence of salt.

Nardus stricta, Aira coespitosa, and Molinia are generally found on sour soils.

Of course, it would not be safe to form a definite opinion on a soil merely by examining the vegetation, but from observation I have made, the grasses named almost invariably are associated with the conditions mentioned.

Moss may either be due to poverty of the soil, a too retentive soil, or inadequate drainage. Until the condition responsible is corrected in spite of superficial treatment in attempts to destrop it it is bound to recur.

The more frequent cause of moss is the bad mechanical condition of the soil, it may be too consolidated so that the water does not percolate freely and it becomes stagnant and infertile, with the result that only the lower forms of growth, like moss, can exist.

Greens in which moss occurs should be rolled with a spiked roller to aerate the soil, and charcoal and lime should be applied.

The temperature of the soil plays an important part in the growth of the plants.

The soil receives heat chiefly by the sun's rays and by warm rains, also by the decay of organic material.

It is of interest to know that soil warmth depends to some extent on colour. Black soils readily absorb the sun's rays, but the rays are deflected by a lighter-coloured soil, which absorbs a much smaller amount.

The night dew caused by the condensing of atmospheric moisture, although it does not provide any appreciable moisture to the roots, has a cooling effect on the soil, and the loss of moisture by evaporation is diminished.

This demonstrates the utility of top dressings to serve as a mulch during dry weather.

Before discussing the fertilising of a soil, the nutrition of the grass plant must be considered. We must know what elements are utilised by the grass and in what proportion.

If a plant is reduced to ashes and the elements separated, it will be found that then it is mainly composed of carbon. This is produced by the plant from the carbonic acid in the air, which is taken up by the green leaves.

Other elements are essential to healthy growth, and these are derived by the roots from the soil. These elements are nitrogen, potash, calcium, and phosphorus.

It must not be overlooked that without the necessary air, water and light, in spite of the soil containing these elements, growth will be at a standstill.

A complete mechanical and chemical analysis of the soil is advisable, at once then it is ascertained whether any of the essential elements are deficient or lacking.

If the soil is deficient in nitrogen, the fine grasses will be starved and there is the possibility of clover developing. Clover is able to fix the nirogen from the air, which it stores up in the nodules on the roots, so that it will flourish on an impoverished soil at the expense of the grass.

As the outcome of extensive experiments, we have compounded a special fertiliser, Carter's Anti-Clover Fertiliser, which encourages the fine grasses and tends to suppress clover. The clover will not disappear at one application, and the treatment must be repeated.

Pearlwort may also be suppressed by judicious application of Carter's Anti-Clover Fertiliser.

When, as is necessary, Greens are regularly mown, at a low calculation, a greater quantity of grass is cut than two crops of hay taken by a farmer from a similar area in a season. The soil in consequence

is heavily taxed, and to support a good turf the food taken up by the grass must be replenished, especially as on a Golf Course, the turf is subject to considerable wear.

In manuring fine turf, there are several factors to be taken into consideration. The effect of a fertiliser, is to a large degree, dependent on the compostition of the turf. With different association of various species of grasses, different effects will be obtained by the same kind of manuring. It will be seen that the composition of the turf should be carefully borne in mind in any manurial treatment.

Certain manures tend to reduce the number of species of grasses forming a turf. This circumstance is not due to the fact that the fertiliser benefits some kinds of grasses and not others, but that the more vigorous species respond to such an extent that the finer grasses are supplanted.

Sulphate of Ammonia for example, when used alone has a stimulating effect on a few coarse-growing grasses, and as a result the finer grasses are outgrown.

Phosphatic manures have a stimulating effect on clover and trefoil, the growth of which is promoted at the expense of the fine grasses. For this reason it is inadvisable to use basic slag or bone meal alone.

Very little plant food enters the soil in a form directly available, most fertilisers must be transformed by bacterial actions.

The mistake is, unfortunately, too often made in applying one heavy dressing each year. It is far better to make light, palatable doses; it is economical, there is no waste, and the grass derives greater benefit.

To maintain a perfectly balanced turf of the different grasses required to form a fine-textured sward, a fertiliser with a uniform stimulating action on the compound grasses is necessary. Carter's Complete Grass Fertiliser posseses the manurial elements necessary to the nutrition of the fine species of grasses. It has a gentle, stimulating effect on the fine grasses without encouraging a coarse growth.

It has been my endeavour to emphasize the relation between the mechanical or physical condition and the fertility of the soil. Unless the soil is of suitable consistency, even though it possesses natural fertilising minerals, without the condition favours the activity of the bacteria to break down the compounds, the soil remains more or less sterile. Moreover, the grass does not derive the benefit it should do when artificial fertilisers are applied.

The Production and Maintenance of Turf.

Lecture given by Mr. A. F. WINGFIELD, of Messrs. Sutton and Sons, Reading, to the Members of the Golf Greenkeepers' Association, 1925.

OF late years much attention has been given to the production and maintenance of Golfing turf, not only in Great Britain, but also in the United States of America. To-day, largely owing to scientific research undertaken by responsible authorities, the work has probably become more systematic than it was years ago. Fortunately for the community as a whole, the vagaries of our climate cannot be controlled by individuals, but it is certainly remarkable how often climatic conditions seem to be opposed to the interests of Greenkeeping. Nowadays the weather is blamed for a multitude of evils, and probably with a large degree of justification, so far as Greenkeepers are concerned. It is undoubtedly a fact that extremes of temperature, excessive moisture or periods of drought are responsible for most of the problems with which they are faced.

Greenkeepers are keen to acquire fresh information concerning the latest developments of turf culture, and the great progress of Golf during the past 25 years has led to an insistent demand for still more systematised knowledge in the art of forming or adapting turf for the game. In some instances much time and money is wasted, not through any fault of the Greenkeeper, but because to the uninitiated the work looks so simple, thus causing a possible under-estimation of difficulties and the adoption of an unsuitable plan, primarily with the idea of saving time or keeping down cost. On behalf of Messrs. Sutton I need hardly assure you that everything pertaining to the science of Greenkeeping receives their careful investigation, and experiments are being continually carried out at Reading to test new theories, to try out new mixtures of seeds and fertilisers and fresh methods of constructional work.

I propose first of all to deal in a general way with the production of turf from seeds, and in doing so naturally the soil is the first thing to consider. It may be a heavy clay, a light sand, or a good medium loam full of plant food. For the purpose of turf production, naturally the last-named is not always procurable, and, indeed, from a Golf Course point of view it is not altogether

desirable, sandy Courses being the best for all-round play. Briefly, then, there are three main types of soil to be considered, and I am going to deal with them as stated.

Before a heavy clay can be made fit (I am leaving the question of drainage to later), its physical character must be improved, and in this connection liming and the addition of some sharp gritty material will play a large part. Ground agricultural lime, which breaks up the organic matter already in the soil and releases the organic nitrogen into a form easily assimilated by plants, may be used. Liming will also have the effect of making the heavy soil more porous and warmer. The lime can be incorporated with the surface soil at the rate of from 4 to 8 ounces per square yard, at almost any time of the year, after the ground has been well dug. It should be mentioned, however, that an application during the winter months will usually do most good. To reduce the proportion of clay in a heavy soil, sharp sand or fine coke breeze may be employed in the proportions of three of sand to one of soil, or two of fine coke breeze to one of soil.

In considering suitable manures it must be borne in mind that heavy soils are, as a rule, rich in nitrogen and potash, and deficient in phosphates. We have already noted that lime is useful, but whilst it releases latent stores of nitrogen, the fact must not be forgotten that it also releases a considerable percentage of potash, which in some cases would certainly have the effect of encouraging a pronounced growth of clover. In most cases for heavy soils, when preparing the seed-bed, the only actual manure necessary is an application, a few days before sowing seeds, of a reliable complete grass fertiliser.

The light soils of sandy districts and those of shallow depth overlying chalk formations are notoriously infertile, and may present difficulties in the establishment of turf from seeds unless appropriate measures are adopted. Turf on soils deficient in organic matter cannot withstand drought, and any soluble plant nutrients added by the application of fertilisers, if not immediately utilised by the plant, are quickly washed down to the lower soil levels. During the preparation of the ground, every effort must be made to add organic matter to these soils in the form of rotted manure or peat moss litter. Either of these will bind the soil and conserve moisture. Where lime is necessary, ground chalk (carbonate of lime), at the rate of 8 to 12 ounces per square yard, is better than ground agricultural lime, which in a sandy soil induces a too-rapid oxidation of what little organic matter is present.

On medium soils a good complete grass manure may be relied on to supply any deficiency of plant food, should this exist. The fertiliser can usually be raked in a few days before sowing grass seeds.

DRAINAGE.—Although this subject is worthy of a lecture of its own, I should like to mention it in a general way. As you are

aware, grass will not flourish on badly-drained soils, and this applies particularly to Golf Courses, where the popularity of the game and the demand for turf in first-class condition for play throughout the year renders the rapid disposal of surface water a matter of paramount importance. Among other things, bad drainage prevents aeration, lowers the soil temperature, and during wet weather has a pronounced adverse effect on the tempers of the players. Although the cost of drainage is sometimes considerable, there is not the slightest doubt that in the end it is money well spent.

In water-logged places, on clay or peaty soils, 6in. pipes should be used for the main drains, and 3in. for the branch drains. The trenches should be nearly filled with gravel or ashes. For large areas on the Fairways 12in. agricultural drains must be employed, and about 2,500 pipes would be required to drain an acre at 18ft. apart.

IRON PAN.—This is a solid layer of rock that slowly forms in certain soils at varying depths below the surface. It impedes the passage of plant roots, checks the rise and fall of the soil water, and, in fact, isolates the surface soil from the subsoil. The conditions which govern its formation remain somewhat obscure, although the absence of lime seems to be one of the primary factors. Where "iron pan" exists it has sometimes been found practicable to lay surface drains to carry off surplus water, and thus save the expense of breaking through the limonite stratum.

On a large slope running down to a Green which is in a natural hollow, special attention must be paid to drainage. To prevent surface water running on to the Green a transverse trench might be cut across the face of the slope.

Where hollow concavities occur on a Green, and water does not get away quickly, it is a good plan to form a "sump" or soak-away, or to put in a porous shaft by digging out the soil and replacing it with gravel or fine ashes.

On Fairways on heavy soil mole drainage is often successful. By drawing, with a tractor, a steel cigar-shaped piercer through the soil at a depth which may vary from 6in. to just over a foot, a channel is left down which the water flows into a ditch or receptacle on the lowest part of the land. On some soils such drains will last for years without becoming choked up.

In the formation of turf from seeds the preparation of the seed-bed is naturally of first-class importance, but I do not propose to refer to this matter at length, as I am sure it is fully appreciated by all Greenkeepers. The work is, of course, a fairly simple matter on light soils, but often serious on clays, particularly after a wet season when the surface becomes glazed, a condition which is inimical to germination.

In regard to the quantity of grass seeds to use, one ounce per square yard is a safe guide in the formation of new turf.

Thick sowings, of course, help to keep down weeds, and this quantity may be doubled where it is considered necessary.

Owing to the smallness of the seed it should be covered with only a very light covering of soil. As a general rule the seed-bed should always be rolled after sowing, and the drier the tilth and the district, the more thorough should be the rolling. There will then be every chance of sufficient moisture working up to the surface to start the seeds germinating.

On light sandy soils, sowings made in August and early September are the most successful. At Meyrick Park, Bournemouth, where Sutton's grass seeds were sown last August, a good result was achieved, and the plant was scythed early in September.

In connection with the destruction of weed seeds in soils it may interest you to know that Messrs. Sutton and Sons have recently been doing this by sterilisation. Under certain conditions some modification or enlargement might be necessary, but the fol lowing hints may be useful. An apparatus should be designed whereby the soil is impregnated with steam and raised to a temperature of about 200° Fahrenheit, thus killing all weeds, weed-seeds, earthworms, and vermin. In this manner an ideal seed-bed is obtained in which the grasses develop rapidly and form a close turf in the minimum of time. An old steam engine is useful for providing the 80lb. steam pressure necessary, and two containers (one containing soil to be sterilised whilst the other is being emptied) are required. A container measuring 6ft. x 4ft. x 3ft. will deal with 3½ tons of soil at a time. Two men should be employed to bring the soil to and fill the containers, whilst a third must tend the engine.

Mixtures of Grass Seeds.—No one species of grass is suitable for producing a perfect turf. Mixtures of seeds used for the Putting Greens, for instance, should consist of the finest varieties procurable, and perennial rye grass (which invariably forms a large proportion of all cheap prescriptions) must be rigorously excluded, as it does not form a close, dense turf.

Of the numerous grasses—some 120 kinds—indigenous to this country, a small percentage only is used to form the special prescriptions such as are used on all types of soils when new Courses are constructed.

Briefly the species of the finer fescues, viz. :—

Festuca rubra,
Festuca duriuscula,
Festuca ovina,
Festuca ovina tenuifolia,
Festuca arenaria,

and certain species of agrostis with one or two others, are relied upon to form the basis of mixtures. The secret of success lies in mixing the different types in appropriate proportion, considering

at the same time the soil and whether the turf will be for the Greens, Fairways, or Tees. Under certain conditions, yarrow, suckling clover, white clover, etc., may be added to the mixtures for the Fairways. This applies in particular upon seaside links, where the soil consists practically of pure sand. On heavy soils seeds for the Tees and Fairways may include perennial rye grass, but on light soils it is wise to exclude this grass. For average conditions a mixture consisting of creeping bent grass (agrostis stolonifera), fine fescues, crested dogstail, and smooth-stalked meadow grass will furnish the best results.

To avoid spending money and time later for the purpose of removing weeds from your turf, sow only grass seeds which have been thoroughly cleaned. Weeds may come from seeds already in the soil, or be blown on to the grass, or deposited there by birds. It is well, therefore, not to add to the weeds which ordinarily find their way into fine turf. Clean seeds save labour in weeding later, and it should always be remembered that the highest-priced seed is really cheaper (by count of seeds), than the lower-priced seed.

There is another method of turf production, namely:—

Vegetative Propagation.—You will all, no doubt, be interested in hearing something on this subject. For some time past experiments have been made with "stolons" of grasses, with the idea of ascertaining whether this way of forming a Green is likely to be successful in this country. We have grown nursery plots from stolons of specially selected types of the agrostis family, and these have furnished supplies for sowing out on trial areas. The idea is to first find the best variety of creeping grass to grow; then sow runners which are laid in a trench. The ground must, of course, be carefully prepared. Well roll after planting. The nursery will, provided the bed is kept fairly damp, give ample supplies of stolons within a year of being planted. It may also be of interest to state that in forming a Green by this method the seed-bed is prepared as for seed. Then take runners from the nursery and chaff them up into small lengths; spread them evenly over the surface, and cover with sifted soil.

The Maintenance of Turf.—On some classes of soil, particularly those on sands, fine grass becomes thin and weeds become prevalent unless great care is taken to maintain the turf in a sound and healthy condition. This naturally leads one's thoughts to top-dressings, and the danger of putting on quite active manures which stimulate growth for a time only, but eventually leave the sward in a worse condition than was formerly the case. It must be remembered that fine grass cannot be maintained on stimulants any more than a human being can, and if reliance is placed in a good complete fertiliser, such as Sutton's, to make up for any deficiency of nitrogen, phosphoric acid, or potash in the soil, much better results will be obtained.

To make well-balanced manures it is necessary to have some knowledge of chemistry, and to know the type of soil to be treated. The mixing, too, is important, as reactions take place, and some of these cause loss or render the mixture less valuable.

Sutton's Complete Fertilisers contain the chemical constituents absolutely necessary to fine grass, and the ingredients composing these manures are suitable for feeding the plant from its inception to maturity.

For top-dressing Putting Greens on light soils a compost of well-rotted manure and soil put on in very light applications during the winter months is very useful. Some Greenkeepers, however, object to its use because of the danger of introducing weeds to the Greens. The use of a fertiliser with an organic basis then becomes imperative, and we claim that ours adequately fills the need.

I may add that I know one Course on sandy soil where certain Fairways have been improved out of all knowledge by very light top-dressings of clay, bush harrowed in during late winter, followed with an application of Sutton's Complete Fertiliser in spring. The clay gives consistency to the sandy soil, and helps to remedy its worst defects, such as susceptibility to drought, and the tendency to produce grasses very liable to disease.

As to seeding thin and bare areas on the Greens, the method of doing this depends much upon the types of grasses present, and the depth of soil. In some cases it is better to prick the ground over lightly and then sow the seeds, covering them with a thin dressing of compost and well rolling. In others the rake must be employed to obtain a good tilth. The seeds should be put in the ground at a depth of about a quarter of an inch. Those sown deeper have difficulty in germinating, whilst seeds on the surface are taken by birds, or become " malted."

However well land is prepared, some weeds are bound to come, and it is true economy to get these out during the first year of growth.

Mowing.—The growth of grass during winter naturally varies according to the weather, but when at all pronounced it should certainly be got rid of, and it is desirable under such circumstances to use boxes on the machines. If the mowings are left on the ground worms are almost certain to increase. On poor sandy soil in a dry summer some protection is afforded to the turf and also a quantity of decayed vegetation is added to the soil if the cuttings are not removed for some time. Where weeds abound it is better, however, to always use boxes, and thus avoid the dissemination of weed seeds.

When cutting newly-sown grass, the scythe is essentially the implement for the work. Subsequently the machine may be brought into use. The sward should be about 4in. to 6in. high when the first cutting is made.

ROLLING.—It is an undisputed fact that on heavy soils more harm is done by over-rolling than by the neglect of this operation A clay soil is made dry by the extra evaporation which accompanied the rise of subsoil water to the surface. Therefore, rolling must be practised with care. It is easy to do harm by injurious rolling in wet weather on heavy soils. The clay may become so puddled that it dries with a "caked" surface, impermeable to air and water, a condition which is ultimately of great detriment to the growth of grass.

Having dealt very briefly with some aspects of the maintenance of turf, I now proceed to a very rapid review of some of the ills to which turf may be subject.

LEATHER JACKET GRUB.—Those of you who have to look after Putting Greens on light sandy soils need no reminder that during the past three months we have experienced a severe attack by this pest. Over twelve years ago we were troubled in the same way, and, doubtless as a result of some peculiarity of the season, leather jackets are exceptionally prevalent at the present time in practically all parts of the country. Some say the plague is due to a scarcity of wasps last year.

The crane-fly or daddy longlegs, mainly in autumn, deposits many hundreds of eggs which quickly hatch out and become the familiar leather jacket grub. Immediately they come into existence the grubs attack the roots of grasses, gnawing them just below the surface of the ground, and the amount of damage caused will depend upon the state of the weather, the character of the soil, and the condition of the grass at the date of attack.

It may also be mentioned that the flies and grubs may be found throughout the summer, but for the most part they change to the pupa state (in which they can do no further harm, so far as eating is concerned) from July to September. At this period of the year every effort should be made to encourage a vigorous growth of grass by applications of fertilisers. When the leather jacket grubs resume their attack the invigorated plant is then in a much stronger position to resist them. To put it briefly, the grass should be kept healthy at all times, but during July to September extra attention must be paid to Greens, which are more likely to suffer from the grub in autumn.

The most safe and effective method of eradicating leather jackets is undoubtedly by the use of Larvoid, a preparation which was originally prescribed by the late Professor Maxwell Lefroy for the destruction of the Golf Green fly, leather jacket, and other pests infesting turf used by pastimes such as golf, tennis, etc.

Two pounds of Paris green mixed into a paste with 1lb. of fresh lime, and afterwards put into 400 gallons of water, and applied to 400 square yards of turf, is sometimes effective. Owing, however, to Paris green being a potent poison, extreme care must

be exercised in using it. The grubs must all be swept up and buried.

A good rolling at night may crush many larvæ which come to the surface at that time. Sulphate of iron is also said to be fatal to leather jackets, but with this I have not noted many successful results.

On established turf a good brushing will sometimes disperse the small black shiny eggs and do them injury, but for the destruction of the grub Larvoid is undoubtedly the most effective.

Limewater, too, with partial success has been tried to bring the grubs to the surface. Also covering the affected turf for about 24 hours with dark cloths. This method is effective, but the grubs must be swept up and destroyeed.

EARTHWORMS.—These humble creatures are undoubtedly of service on arable land, but on a Putting Green or in Fairways, particularly on heavy soils, they constitute a serious detriment.

The use of a proprietary worm destroyer, obtained from a reliable house, is certainly the best method of eradicating earthworms.

Recent experiments have proved that corrosive sublimate (bichloride of mercury) and limewater are only partly effective, but should it be necessary to use either, the following directions may be useful:—Two or three ounces of corrosive sublimate should be dissolved in 50 gallons of water, and this may be applied to about 100 square yards of turf, afterwards being watered in. No injury to the grass should follow, but it must be remembered that corrosive sublimate is a violent poison, and the powder must not be left about. Use a wooden receptacle for mixing the solution in. Sulphate of ammonia has sometimes been added to the corrosive sublimate, but the results do not justify its use, as the efficacy of the corrosive is not increased thereby.

Limewater may be employed on the Fairways where a water supply is not laid on. A great disadvantage of this method of treatment is that the earthworms are not killed. Use a peck of fresh lime to 40 gallons of water. Stir the solution, and then leave for two or three days, when it may be applied. The worms must be swept up directly they appear on the surface.

FAIRY RING FUNGUS (Marasimus oreades).—This disease is readily propagated by means of mycelium in the soil—a greyish growth with an unpleasant odour.

The ring of grass attacked is usually killed, and the fungus then spreads outwards and subsists on a further enlarged ring during the following season. Often the weed grass, poa annua (annual meadow grass), takes the place of the finer grasses.

Such fungoid growths as marasimus oreades are usually caused through a poisonous or toxic condition of the soil, which is sometimes set up by the use of nitrogenous and acid manures.

Sometimes the use of kiln dust will make the soil acid, as this material is usually acid in reaction.

The affected place should always be cut right out and the soil removed and burnt. Take out all the mycelium, or the smallest portion left will cause further trouble. It is a good plan to dress the holes with Sutton's Fairy Ring Destroyer (1oz. per square yard), and also where the disease is noticed on a small scale at least one foot outside the ring. Repeat the operation, if necessary, two or three times, at intervals of one month. No harm will be done to the grass.

Clover in Putting Greens.—The past two summers have seen a great increase in clover on Putting Greens, a fact which causes Greenkeepers more worry. Where the trouble persists this year, much may be done during the summer months to check the plant by occasional dressings of Sutton's Anti-Clover Mixture. The preparation should be applied in dry weather at the rate of 2oz. per square yard. Creeping stems should first be raked up and scythed off. Another effective method of discouraging clover is to shave closely the patches, either under a burning sun or during spells of sharp frost. If the plant is eradicated in the young stage when first noticed, much work later on will, of course, be saved.

Moss.—Moss is, perhaps, the least exacting form of vegetation, and as such it may be said to exist under soil conditions unable to support any other form of plant life. If there is much moss in fine turf, and the Green does not lie wet, then impoverishment is the cause, and the remedy is obvious. A thorough raking (or harrowing if on the Fairways), followed by the use of a good fertiliser, will work wonders. If there is any surface water about, it is essential to drain it off before attempting other treatment. Draining, raking, or harrowing, and feeding the soil, are the three necessary remedies. For small areas Sutton's Moss Destroyer (1oz. per square yard) may be used. Lime does not appear to have much effect in discouraging moss.

Turf Nursery.—Some clubs are fortunate enough to have fine natural turf throughout the Fairways from which supplies can be drawn, but others are not so fortunate. These should provide a turf nursery from which materials for patching the Greens can be obtained. Many a Greenkeeper has spent hours in "fining" down the best available turf in out of the way places, when, had suitable areas been chosen, prepared as for a Green, and sown down with fine grass seeds, much labour might have been saved. We are not so fortunate in this country as in America, where I believe they sow down large areas with a view subsequently to using the turf for repair work.

Two or three sheltered sites on the Course should be sown at different dates in order that a supply of turf may be always available for renovating work.

Problems of Fertility.

Lecture by Mr. Watts, at London Stone Hotel, of Messrs. Sutton & Sons.

THE problems of fertility which come before the notice of a large seed-growing business are numerous and varied, relating as they do to the culture of many different crops. The upkeep of turf, for example, meets with certain difficulties associated with the soil, and I propose to deal briefly with a few of the more frequent, endeavouring as far as possible, to explain the underlying causes.

Soil problems, of course, are closely connected with fertility, but fertility cannot be defined in a few words, as so many circumstances are involved. The value of the soil does not depend upon its physical condition, though this must always be a factor of considerable importance. Water supply, aeration, temperature, chemical composition, and the solubility of the plant food present, all contribute to fertility. Climate influences the value of a soil, and altitude and aspect are also of importance. The nature of the subsoil calls for some consideration, as well as the contour of the land and even the colour of the soil. Most important of all, perhaps, is the question of the micro-organic life present.

Soil is a very familiar object to all of us, yet we know comparatively little of its complex nature or the wonderful way in which it has been rendered fit for the growth of countless generations of plant life. It is tolerably certain that the surface of the land was at one time covered entirely with rocks, the long-continued decay of which has gradually produced soil. The principal soil-forming rocks are known as igneous, aqueous, or organic, according to their origin.

Igneous is a term relating to fire, and embraces all rocks of volcanic origin. Granite is perhaps the most familiar example, occurring at Aberdeen, Dartmoor, and the Wicklow Mountains of Ireland. Granite consists essentially of quartz, felspar, and mica, and contains potash and silica. It weathers down into a rather stiff soil which is not particularly fruitful. Basalt is another common type of igneous rock, and is merely volcanic lava which has cooled quickly. It is richer in lime than granite, and breaks up with comparative rapidity, yielding a more fertile soil. The plain of Antrim, in Ireland, is the best-known instance in Great Britain of soil formed from basalt.

Aqueous rocks are perhaps of greater importance from the soil point of view. They were deposited at different periods in the long history of the world, by currents of water, in a similar way to which alluvium is even now being formed at river mouths. Just a lump of soil stirred into a glass of water will settle into various layers according to the coarse and fine material present; so immense tracts of sands and clays have been formed from aqueous rocks.

Organic rocks contain no mineral substances, but are formed from the remains of animals or plants. Limestone and chalk are typical examples of the kind composed of the accumulated remains of certain minute shell-bearing creatures. Limestone is sometimes very pure and hard, but in other cases sand or clay is present, giving rise to sandy limestones and marls. Chalk is usually softer and very pure.

Dolmite is another form of organic rock, and consists of calcium and magnesium carbonates. It occurs in large masses known as magnesium limestone, and produces a thin poor soil on which it is extremely difficult to maintain a satisfactory sward of grass.

Coal and peat are organic rocks produced by plant remains. Coalfields are of immense value for their mineral wealth, but the soil in their neighbourhood is universally of poor quality and unsuitable for the formation of Golf Courses. Peat is the decaying mass of plants that accumulates wherever drainage is defective. It is very different in texture from all other soil forming materials. Owing to the immense amount of organic matter present, soils formed from peat are rich in nitrogen, but they are generally deficient in all other elements of plant food.

Gravel is the name given to water-worn fragments of rock that may form part of any soil. It is, however, more often found in conjunction with those of a light nature. Where gravel is much in evidence the soil, as a rule, is worth but little, but in the presence of clay or lime we have richer gravel soils which, notwithstanding their open texture, are perfectly suitable for the establishment of fine turf provided they are sufficiently endowed with organic matter.

Shale is nothing more than layers of hardened clay, and slate is of much the same character. Where they predominate, the soil is cold and stiff. Sandstone is a cemented mass of sand particles.

Surface rocks are now chiefly confined to the more mountainous region of Britain. They consist largely of slate, shale, granite, basalt, and gneiss, and cover large areas in the Scottish Highlands, northern England, Wales, Devon, and Cornwall, and the coast of Ireland. There the quantity of soil is small, but elsewhere Nature has been at work for countless ages, gradually decomposing the surface layers of rock.

The full story of the formation of soil would take a long time to tell and it is sufficient to say that the action of the weather, for an incredibly long period has been the chief agent. No rock, however solid, can resist the alternate contraction and expansion caused by continual changes of temperature. Frost, too, is a most powerful weathering agent, a tremendous force being exerted by freezing water that has lodged in the crevices of rock. In many other ways seemingly insoluble rocks are slowly and constantly broken up by water, carbonic acid, and oxygen.

In many districts the soil is derived directly from the underlying rock, and the process of breaking-up is clearly shown in the intervening layers. The top of the solid rock is seen to be splintered and above this a layer of broken fragments exists, together with a small

amount of loose material, which gradually increases in proportion until the subsoil proper is reached. This in turn merges into the top or fertile soil, the distinction being quite pronounced in cultivated land. In undisturbed areas the top-soil is perhaps again covered by a thin layer of vegetable mould formed from the decay of plants.

Sometimes the top-soil is formed from materials transported from a distance by glaciers or streams, and weathered down on the spot. Such soil covers the greater part of Scotland, the northern half of England and much of Ireland. It varies in texture from the heavy " boulder clay " to the light soils of the " drift."

The formation of the organic part of the soil is even more remarkable, for by this agency masses of sand and clay produced from rocks are made fertile and suitable for the growth of crops. For the supply of this indispensible part of the soil we are dependent on the activities of minute living organisms or bacteria of such dimensions that only a powerful microscope can distinguish them. There is undoubtedly a great number and variety of them in the soil. It is difficult to realise that such insignificant creatures make all the difference between fertility and a barren soil, yet I suppose it is not too much to say that all life would be impossible were there no soil bacteria.

Long before vegetation, as we know it, existed, soil bacteria were engaged in the formation of the organic matter on which the earliest growth of lichens and moss subsisted. The decay of these humble plants (brought about by soil bacteria) gave rise to fresh organic material, and in due time new forms of vegetation appeared. As generation after generation of plant growth returned its residues to the soil, the organic matter so indispensable to plant life was gradually built up and increased.

This residue of plant life, or humus, as it is commonly called, is the principal soil-forming element and contributes very largely to fertility. It is the chief natural source of nitrogen in the soil. As grasses depend on a free supply of nitrogen, it is specially important in the case of growing turf for an adequate supply of humus to be maintained. Fertility will vary in direct proportion to the amount present. Rich land may contain up to 5 per cent. of actual humus, and peaty soils 10 per cent. or more. Where less than 5 per cent. is found, soil would be considered poor, and land altogether devoid of this essential substance is quite barren, as for example the great deserts of Asia and Africa.

In addition to its contribution of nitrogen, humus greatly improves the texture of light soil by increasing its retentive powers, but on the other hand its presence in heavy land is essenial to make it more open and porous. In all cases humus does good service in rendering many artificial manures available to the growing plants.

Soil bacteria are not only responsible for the decay of vegetable matter and the release of stores of valuable plant food, but they assist by absorbing nitrogen from the air and building up compounds that are easily assimilated by plants. It is the minute bacteria which

decompose farmyard manure in your compost heaps, and transform it into such valuable top-dressing. They are the only means whereby the complicated structure of dead plants is broken up into simpler substances, and these again converted into food for the living and growing plants.

It is therefore important by all possible means to encourage the work of soil bacteria. They need moisture and a soil sufficiently porous to admit air. The presence of mineral plant-foods is also necessary for their beneficial work. These organisms cease to operate at low temperature as well as at a greater heat than 130 degrees, although they are by no means destroyed in such extremes. The production of humus is also more or less restricted in the absence of suitable chemical ingredients with which the newly-converted plant food can combine.

It is important to bear in mind that soil bacteria are quickly destroyed by gas lime, large doses of salt or sulphate of iron, and even by heavy dressings of quick lime.q The failure of the grass on a Putting Green may conceivably be due to some such application. A prolonged spell of wet weather is another reason for the partial destruction of soil bacteria in the case of clay lands. Owing to the saturated condition of the ground the bacteria are unable to obtain the air so indispensable to their existence, and grass failure sometimes ensues. Such conditions afford an opportunity for the development of various fungoid pests and are a fruitful cause of the dark-coloured slimy areas seen on water-logged hollows of some Greens during a succession of wet weather.

Curiously enough, soil bacteria are preyed upon by other forms of minute life known as protozoa, and where conditions favour the existence of protozoa, trouble may result. The harmful protozoa, however, are destroyed by heating soil to a temperature of about 200 degrees, an ordeal that does not injure the bacteria in any way. On the contrary, they seem subsequently to mulitply with great energy with a corresponding increase in fertility. This interesting fact has proved of material influence in the great success of the sterilising process introduced by my firm in connection with the sowing and rapid establishment of bowling greens. In that case, turf fit for really hard wear has been produced in the short space of nine months, and weeds were practically non-existent. Some day this method may be universally applied to Putting Greens, as it must prove of immense value in the rapid production of fine turf.

Soil bacteria abound near the surface of the land and do not usually live below a depth of eighteen inches. For this reason subsoil is more or less barren and unsuitable for plant life, there being no bacteria and therefore no humus. Considered from the point of view of establishing a Golf Course, the top soil should be from six to nine inches deep, and where less is present, the land would be termed thin and is usually poor.

The ideal soil for a links would be a fairly deep, light loam, over-

lying a subsoil sufficiently porous to ensure effective drainage. Unfortunately, land of this character is not often available, and between stiff heavy clay and loose sand or nearly pure chalk are innumerable grades of texture, which reflect on the value of the land for turf purposes. By inspecting the broken earth when it is nearly dry, some idea of its quality may be formed from colour alone. Chalk soils may be nearly white, and sandy land is usually light in colour unless peat is present, when a brownish-black hue results. Some moorland peat soil is very dark in colour. A light brown colour is the property of ordinary medium land, but fertile loams possess a uniform hazel tint or deep red colouration. Stiff soils over chalk usually dry off to a yellowish-brown tint. Many clays are also brown, but the colour is usually dull and quite distinct from that of more fertile medium land. Poor clays may be yellowish or grey, and the worst heavy soils have green or white tints. Where patches of different colour are present it is to be suspected that the soil is thin and indifferent as to quality.

For purposes of turf cultivation it is more or less convenient to grade soils into the following general classes:—

1. Light, sandy soils.
2. Sandy peat soils (heathland) and true peat.
3. Medium soils embracing light loams, alluvium, and sea marsh.
4. Clay soils, and all those of extremely fine texture.
5. Calcareous soils.

We will now for a moment consider the peculiarities and difficulties of each division.

LIGHT, SANDY SOILS.

Sand is the name applied to fragments of silica, quartz, and other very hard materials ranging from about 1/500th of an inch to 1/50th of an inch in size. The commonest constituent of soil, it is present to the extent of 30 per cent. even in the case of very heavy clay loam.

Soil containing no sand would prove quite unmanageable for purposes of cultivation, and even the brick clay, containing from 10 per cent. to 20 per cent., can only be worked with extreme difficulty. Not until the fraction of sand exceeds 30 per cent. or 40 per cent. can heavy soils be cultivated with relative freedom. The importance of sand as a mechanical constituent of soils is therefore readily apparent.

There are, of course, immense tracts of fairly pure sand lying along the sea-shores of this country. Large areas of inland country also consist of sandy soil of a rather more mixed character. In the South of England, the Bagshot beds of Aldershot and the New Forest, and the lower greensand of West Surrey and Hampshire, are familiar instances of inland sand. The Oolite formation also produces sandy regions in Northamptonshire and the East Midlands. Further north are found the loose, sandy soils of the Bunter beds, which give rise to such barren areas as Sutton Park, Sherwood Forest, Cannock Chase,

and Delamere Forest. The very coarse millstone grit soils are responsible, too, for large areas of high-lying heathland where the ground is particularly poor and hungry.

Desirable as it is, from a physical point of view, sand contains no actual plant food, and the fertility of a sandy soil depends on the amount of clay and organic matter present. To meet the requirements of turf for Golf purposes, sandy soils ought to contain at least 10 per cent. of clay if the subsoil is loose and the water-table low. Against drought or excessive heat, a clay subsoil is some safeguard, and where the water-table is high or the atmosphere continually humid less difficulty is generally experienced in maintaining a verdant sward of turf, notwithstanding the absence of clay in the surface soil. But should none of these favourable circumstances exist, soil in which the percentage of clay is less than 10 suffers severely during drought and would be termed very poor.

A soil which is practically pure sand to a depth of several feet presents the utmost difficulty in the establishment of turf, and success can scarcely be hoped for without a covering of some richer and more adhesive loam.

The outstanding difficulty connected with sandy soils is their inability to hold moisture and humus. Organic manures must therefore be constantly applied in order to maintain and increase the supply of humus. The retentive power of the soil for water and manurial matter will then be greatly improved and a firmer soil texture should result. On very poor sandy areas it may even be necessary to build up a new surface altogether by repeated dressings of compost and mineral salts before a sound turf can be established.

Sometimes it is said that fine turf cannot be maintained unless the soil is starved. Probably this idea originates in the fact that injudicious fertilising treatment may bring on an undesirable coarseness or possibly a crop of Poa annua or clover. Hence the mistaken notion that soil cannot be too poor for the purpose of golf. As a matter of fact the opposite is the case, as the encroachment of weeds and moss is often directly due to failure in maintaining a thick sward of grass on account of low fertility.

Consider for a moment the enormous crops of grass removed from a Golf Course in the ordnary routine of mowing. A hay crop of 1½ tons per acre will tax the soil to the extent of about 49 lbs. of nitrogen, 27 lbs. of phosphates, and 50 lbs. of potash, but far more than this is removed by the repeated close-cutting necessary to maintain a fine, dense turf. It has been estimated, indeed, that lawn cuttings remove as much as 50 lbs. of nitrogen, 28 lbs. of phosphates, and 30 lbs. of potash, in a period of three months, so that the equivalent of a number of hay crops is removed from a golf links in the course of a single year.

If, in addition to their natural infertility, sandy soils undergo such a heavy drain on their resources, the question of fertilising treatment deserves the most serious consideration.

It should be a recognised necessity always to have in course of accumulation a supply of suitable material for winter top dressing of Putting Greens on light soil. Well-rotted manure, leaf-mould, and the best light top-soil obtainable forms a useful compost, and it is desirable for heaps tostand at least a year. When required for use the compost should be sifted and only the finest portions applied to the Greens.

The applications of compost should be regarded purely as a source of humus, as the amount of plant food added to the soil in this manner is relatively small. With regard to actual manures, it is important to bear in mind that the growth of vegetation is limited by the smallest amount of any single element of plant-food present. Sandy soils are notoriously deficient in practically all plant-foods and it is wastful to experiment with incomplete manures. The usual method of giving light dressings of organic compost during winter, supplemented in spring by the use of a compound chemical fertiliser, can scarecly be improved upon.

It must be said that light soils in general are in favour for Golf Courses, as their various defects can usually be overcome in a satisfactory manner, and there are a number of natural advantages. For one thing, many areas of light soil are too poor for reclamation or cultivation, and have remained unenclosed as forests and commons. In situation they are removed from agricultural and industrial activities, so that the game of golf is enjoyed with an unrestricted sense of freedom. As a rule, the land is sufficiently undulating to afford full scope to the architect. Above all, the subsoil is usually very porous and there are no drawbacks to winter play.

The nature of any particular soil can usually be understood from a study of the wild herbage. Sandy soils are distinguished by a natural flora that is well adapted for the situation. Many plants found thereon are provided with stubborn, creeping roots, that explore the soil for the little nutriment available. This character is no doubt well known to Greenkeepers who have had occasions to deal with an invasion of weeds on light soil. A peculiarity of many of the plants is that they are able to endure conditions of low water supply; by an arrangement of the cells, the leaves close in dry periods and a check is thus suffered on the amount of moisture given off.

An important kind of plant common on light soil is that which dislikes lime. This order includes such grasses as red fescue, hair grasses, and a number of bents. Where these abound on Putting Greens and Fairways, it is not certain that the free use of lime is essential or even desirable. As a matter of fact, decidedly alkaline conditions might prove harmful to the grass, whereas a slight degree of acidity is not altogether unfavourable to the existence of fine turf on certain soils. But where the acidity is so great that moss threatens possession of the turf, the moderate use of carbonate of lime may do good in reducing the unhealthy state of affairs without rendering the soil actually alkaline.

The fescues and bent grasses form some really excellent pieces of turf on sandy soils, and prescriptions of grass seeds for sowing on such should always contain these species. Agrostis vulgaris (common bent grass), is particularly in favour on account of its dwarf foliage, creeping habit, and capability of withstanding hard wear. In combination with other suitable sorts it iis responsible for a densely matted sward.

Unfortunately it is a matter of the greatest possible difficulty to obtain true seed of Agrostis vulgaris owing to the extraordinary resemblance it bears to other forms of Agrostis, which are coarse weeds and would do untold harm if sown on a Putting Green. From time to time, my firm has had the opportunity of examining plants grown from seeds purported to be Agrostis vulgaris, which proved nothing better than the tall, coarse-leaved fiorin—a variety quite unsuited to the formation of Putting Green turf.

Smooth-stalked meadow grass also has a preference for light dry soils, and may be usefully employed under many circumstances. Sweet vernal is another plentiful grass, but is not regarded with favour on account of its rather wide, prominent leaf.

Practically the only leguminous plants flourishing on sandy soils are gorse, broom, kidney vetch, and a number of trefoils. Bracken and heather are prevailing plants, the presence of which is largely due to a distaste for lime. Dry areas will find the common heather and fine-leaved heath, while cross-leaved heather prefers the damper places. All the heathers denotes infertility, and in this connection they are often associated with lichens, mosses, and various sedges.

The presence of spurrey, sandwort, sheep's sorrel, wild thyme, and hare's-foot trefoil is a common indication of poor, dry soil, and under such conditions the bulbous buttercup can be quite troublesome.

HEATHLANDS.

Between sandy soils and true peat are a number of types known as the sandy peats and silty peats, which constitute larger areas of heathland and moorland in this country. The heathlands are probably the most favoured of inland situations for golfing purposes, and in the opinion of many the best heathland course is quite up to the standard of the average seaside links.

As a rule, the surface layer of peat is of no great depth, and good black soil is often found immediately beneath. This may be succeeded by layers of ironstone, yellow earth, clay, or subsoil, which consists for the most part of small pebbles. With proper management, sandy peat soils are generally to be cultivated with a fair degree of success, and, although the question of drainage must always receive close attention, the task of forming a Golf Course on such land should not prove an insuperable one.

Perhaps one of the most important matters is the selection of seeds, as neglect to employ a special prescription of grasses might result in serious disappointment under the somewhat exacting condi-

tions prevailing. Generally speaking, the grasses sown should consist of bent species, hard fescue, sheep's fescue, fine-leaved sheep's fescue, red fescue, and possibly the valuable creeping fescue, blended in suitable proportions.

Heathlands have their own particular type of vegetation, which embraces such forms as conifers, heather, bracken, gorse, mosses, and a great variety of sedges and rushes. In addition to the grasses mentioned above, such species as the purple melic, heath grass, and mat grass, are very familiar on heathlands. In the North of England, the blue moor grass is a feature of high-lying heathlands, and the ubiquitous Yorkshire fog is present to a large degree.

As a rule, the more valuable fine grasses are found only in isolated patches, and, although the natural herbage may be admirably adapted for the " rough," possibly the entire area intended for the holes may need bringing under the plough and many tons of soil imported for the Greens. Occasionally the existing vegetation is made to serve for Fairways with merely such amendments as can be effected by mowing, rolling, and top-dressing. The result, however, is not altogether first class, and some very indifferent lies are at times obtained.

Heathlands are particularly subject to the formation of a solid layer a foot or more beneath the surface. This is due to the action of iron salts on particles of earth, and the absence of lime seems to be one of the main factors governing its formation. Surface crops suffer severely from the effects of an underlying "moor pan," or "iron pan," and in the case of Putting Greens the obstructing layer should be broken up with a subsoil plough before other work proceeds. Where the depth of the " pan " is such that it cannot be broken by subsoiling, the only alternative is to lay shallow drains to deal with surplus water.

The existence of an " iron pan " or even an underdlying stratum of clay is often accompanied by the formation of peat, of which a large amount may in time accumulate. In extremely difficult cases, the accumulation of decayed vegetable matter, extending over centuries of plant growth, forms a considerable depth of peat, and under such conditions acid fermentation sets up owing to the exclusion of air.

The immense amount of organic matter present makes it essential for peat soils to be thoroughly drained and well limed, while they must be supplied with mineral manures before any attempt at cultivation can be made. The vegetation of true peat soil is invariably confined to Nardus stricta and other rough grasses, with innumerable types of sedge and rush, and fortunately an endeavour is seldom made to lay out a Golf Course on a typical peat.

MEDIUM SOILS.

It has been suggested that 10 per cent. of clay is sufficient to render a light soil suitable for the establishment and maintenance of fine turf for golf.

Where the percentage of clay rises from 10 to 20, the soil would be

termed a sandy loam, and by gradual degrees the sandy loams pass into the true loams containing 20 to 30 per cent. of clay. This particular section embraces some of the most fertile soil of the country, and as a rule such land possesses a nice intermediate texture. Where the soil is a rather deep, rich loam resting on a porous bed, ideal conditions exist for the maintenance of fine turf. But on most loamy soils there should be little difficulty in maintaining Greens in first-class condition, as an adequate amount of organic matter is usually present and drainage is satisfactory, yet sufficient water is retained to assist the grasses during spells of drought.

Possibly the only naturally difficult type of loam is that in which the sand present is of rather fine texture. The soil is then apt to become sticky in wet weather, and dries to a rather hard surface. Under such conditions aeration is defective and bacterial life poor. An example of this unsatisfactory type of loam is met with in the Hastings beds, and before good results are achieved such land must be treated more after the manner of clay. By dressings of sharp sand and the incorporation of rotted manure, a satisfactory change in soil texture will result.

Naturally the treatment of loamy soils must vary somewhat according to the actual proportions of clays and humus present. Dressings of sharp sand often prove beneficial in rendering the surface more porous, but usually there is sufficient organic matter to obviate the necessity for compost.

Loamy soils being of such diverse character, it is impossible to remark very definitely in regard to the type of vegetation present, but it may be said that chickweed, groundsel, goosefoot, and nettles, are often found on soils of medium or loamy texture and usually denote a fertile condition.

The grass tribe is highly varied. Indeed, almost any variety of grass will succeed on loamy soils, and if sufficient consideration is given to treatment of the Greens—both manurially and physically—there is no reason why the valuable fine grasses prevalent on drier soils should not be made to predominate. To this end the liberal application of sharp sand will be most helpful in combination with the use of a well-balanced manure containing the requisite proportions of nitrogen, phosphates, and potash, necessary to the growth of fine grass, but anything approaching prodigality in the manurial treatment of loamy soils should be avoided.

Alluvial deposits form an important division of loam soils and occupy large tracts of land in Cambridge, Lincoln, Sussex, the Fens, and various parts of Scotland. They are created out of the suspended matter carried down by streams and deposited wherever the speed of the current diminishes. Much new land is continually formed in this way, especially at the mouths of the great rivers. As the main channel silts up, new outlets are made, with the formation of such deltas as are found at the mouths of the Rhine, Nile, and the Ganges where the alluvium covers an area of 40,000 square miles, and is said

to be more than 500 feet deep in places. In England, the Holderness of Yorkshire, has been formed by alluvium, and the Wash is likewise gradually filling up.

Alluvial soils are formed from many kinds of rock and are usually very fertile. They present no special difficulty in regard to the establishment of golfing turf except where waterlogged conditions prevail. Drainage is always liable to prove a serious problem owing to the difficulty in providing a satisfactory outlet for surplus water. Often a mild kind of peat accumulates in alluvial soils that are imperfectly drained and marshes are formed. Here the carnation grass and other sedges do well. Meadow lychnis, lady's smock, arrow grass, yellow rattle, brooklyme and Persicaria are other familiar plants. The common horsetail frequently appears and is a certain indicator of subsoil water.

Among the grasses that frequent marshy places are the coarse-leaved marsh bent, or florin, floating foxtail, reed meadow grass, floating meadow grass, tufted hair grass, and the common reed or rush. Timothy and tall fescue, though not necessarily marsh grasses, grow to a gigantic size in such situations.

On those considerable areas of marsh near the sea, the subsoil water become so highly charged with salt that the vegetation undergoes a complete change. An entirely new group of plants is met with, and their peculiarity is to store up quite a large amount of salt in their tissues. The sea aster and sea pink are of special note in this respect.

The wild grasses of salt marshes include such species as Poa maritima, Poa distans, and Festuca arenaria, and form some remarkably fine stretches of virgin turf. Owing to the conditions under which they live, these grasses have become more or less dependent upon vegetation propagation for their increase, and have seed habits which are only very feeble. Many acres of such turf have been stripped and removed for laying on bowling greens, but unfortunately the grasses in question do not always thrive when removed from their natural situation. Being unbale to stand the severe competition brought to bear on them, they are eventually superseded by local grasses or weeds, so that in course of time. imported from sea marshes is liable to change its nature.

There are, of course, possibilities connected with sea marsh grasses from the point of view of seed production. By careful selection over a number of years my firm succeeded in evolving a strain of Fescue arenaria which possess the great merit of producing fertile seed and will flourish in almost any situation. It still has the beautifully fine texture, creeping hbaits, and excellent colour of the original wild stock.

CLAY SOILS.

We have already noticed that loamy soils of such fine texture as the Hastings beds are liable to become sticky in wet weather. This

sticky or plastic nature increases in proportion to the closeness of the texture, and where the bulk consists of very fine particles a heavy or clay soil is formed. The difference between light and heavy soils, in fact, is more largely a question of texture than any great variation in the chemical compostion of sand and clay.

It is simply the extremely fine texture of clay soil that gives rise to its characteristic tenacity and favours the existence of colloids or gluey bodies. Owing to the minute size of the particles, clay soils are able to hold a large amount of water, and often the quantity present is sufficient to exclude air from the soil; under such conditions the ground becomes waterlogged, a low temperature prevails, and the soil is rendered more or less non-productive.

Heavy soils are common in all parts of the country, the Weald, London, Boulder, Oxford, Kimmeridge, and Lias, clays covering immense tracts of land. In addition, much poor clay soil is derived from granite, slate, and shale.

Clays as a rule contain more plant food than soils of lighter texture, but are not so fertile owing to their liability to be cold, wet, and poorly aerated. On this account, clay soil is not well adapted for the maintainance of high-quality turf, and is, perhaps, the least satisfactory of any on which to construct a Golf Course. Without remarking on the flat and monotonous character of clay lands, it may be said that too much adhesive material is present for the maintenance of Greens in perfect condition for winter play. Unless constructed in a very careful manner, Tees are particularly liable to suffer severely in wet weather.

Under such conditions, it is manifestly impossible to reproduce the ideal playing conditions of Courses laid out on lighter formations, but much may be done to minimise existing discomforts. Very great improvement in the physical nature of the soil can be brought about by the regular use of sharp sand, coke breeze, and other gritty materials, and it should be a recognised necessity for Greens on heavy soil to receive several applications of this kind at intervals during winter. Sea-sand is invaluable for promoting a clean, dry playing surface, and has the additional merit of "fining" coarse grass and encouraging the development of the most desirable species. Dressings up to one-eighth in depth may be given on occasions, and at this rate a cubic yard of sand would cover about 300 square yards of surface.

To ensure the best results the Greens may first be well perforated with an implement of the nature of the "Sarel" spiked roller, and the sand evenly broadcast. Work the dressing into the turf with a broom or back of the rake, and, weather conditions permitting, lightly roll and sweep the Green for a day or two following the application.

According to our erperience, a top-dressing of fine charcoal is also exceedingly useful when a Green has become badly saturated. A pound per square yard, of pieces ranging between quarter-inch and

half-inch, will usually work wonders. After spreading the charcoal over the unsatisfactory parts of the Green, a light roller or spiked implements should be put over, and the charcoal, being a powerful absorbent, will rapidly relieve the soil of moisture.

Worms may not always appear particularly troublesome in Putting Greens on heavy land, but the continual movement of these creatures in the soil and the amount of mud thrown up to the surface make it difficult to maintain a true sward. Occasionally there is need to expend much labour in sweeping or switching the turf, and this is certainly not to the advantage of the grasses. Beyond doubt, worms are harmful to turf, and should certainly be eradicated wherever they are numerous. The expenditure entailed must inevitably prove well repaid.

Drainage is usually a serious problem on clay soil, and it is invariably necessary to insert a proper system of pipes before sound turf can be maintained on the Greens. In this connection, the requirements of each Green will differ, and individual treatment is imperative. It is impossible to lay down definite rules beyond the fact that it is well for the main drain to follow as closely as possible the natural slope of the land, and for an appropriate number of branch drains to be joined up at rather acute angle.

In view of the impervious nature of clay, trouble is to be expected with surface drainage, and in extreme cases the top few inches may be saturated, while the underlying soil is comparatively dry. For this reason deep drainage of clay soil is to be avoided, and particular care should be taken to fill in the trenches with porous material to within five or six inches of the surface.

If financial considerations permit, it is undoubtedly an excellent practice to insert a layer of ashes under all the Greens in addition to a proper system of drains. On such a foundation, six or nine inches of lighter soil could be placed before completing the Green by laying turf or sowing seeds. There is not the slightest doubt that a provision of this nature would be most successful in solving the problem of maintaining winter Greens on clay soil.

Proper drainage of clay soil will not only deal with an excess of water, but during dry weather more moisture will actually be available to the turf, so that drained land suffers less from drought and does not crack so badly. Drainage is responsible for an earlier and more prolonged growth of grass, and improves the soil texture owing to the gradual removal of the finest clay particles in the drainage water.

It is almost unnecessary to remark that rolling on clay soil needs the greatest possible care, or serious injury to the turf may be done. A light wooden roller is almost all that is necessary for the Greens during summer and autumn, although in spring it may prove needful to retort to a heavier implement in order to counteract the effect of winter frost. There is a proper time for such rolling, and good

results are not likely to be obtained when the top soil is charged with moisture. Only when the surface is actually dry and the underlying soil just moist should the heavier roller be put on.

Another drawback, almost entirely confined to clay soil, is the difficulty of preparing the ground for sowing with grass seeds, and experience is needful for the recognition of that particular state between moist and dry, which is favourable to the formation of a tilth. Renovating sowings of grass seeds on heavy soil often fail, simply because a proper tilth has not been worked up. On small bare patches, the rake must be kept at work until the soil is well crumbled. In the case of large areas, it is almost impossible to break the surface sufficiently by merely going over once with a heavy harrow. Two or three turns should be the rule, and the ground must next be harrowed with the reverse side of the implement to fine down the surface. Next, carefully roll to ensure consolidation and break up clods. Subsequently give another light harrowing to provide a seed-bed.

Many clay soils are deficient in lime, and where it is likely to prove beneficial to the grasses, moderate dressings should be given. Latent stores of nitrogen will then be set free and the texture of the soil improved by the flocculating or granulating effect of the lime. But if bent grasses are present to any degree it may not be desirable to use lime. In that case the stiffness of the soil must be reduced by repeated dressings of sharp sand. With regard to actual manure, in most cases a Spring and Autumn dressing of a good complete grass fertiliser, mixed with sand, may be depended upon to make good any shortage of plant food.

Indications of soil in which clay is a strong element, are afforded by the presence of coltsfoot, silverweed, meadow crowfoot, and primrose, but owing to the close texture of the land there is a less favourable seed-bed for weeds and they are not so much in evidence as elsewhere. Perennial rye grass, meadow fescue, foxtail, cocksfoot, rough-stalked meadow grass, crested dogstail, meadow barley, and fiorin, are familiar species.

CALCAREOUS SOILS.

Calcareous soils are of a very diverse nature, ranging from the thin white land of the various Downs and Wolds, to the rich marl of the Lower Lias and Keuper formations. As the latter partake more of the nature of heavy soils, for purposes of treatment, they may be regarded as such. Otherwise it may be said that calcareous formations are excellently adapted for golfing purposes inasmuch as drainage is efficient, and without undue difficulty a fine sward of grass can usually be established. It is as well, however, to bear in mind the particular defects of calcareous soils. They are all alike in respect of their slipperiness when wet, and liability to cake on drying. Moreover, decay is very rapid, and organic matter is easily lost.

Sharp sand will prove beneficial on chalk soils, and in every case the regular use of organic manures is of the utmost consequence. From the manurial point of view, many chalk soils can be said to resemble sands in that they are light and hungary, though less effected by periods of drought. There is usually a pronounced lack of potash, and dressing of this artificial are directly beneficial; where use is made of a complete manure, however, the further addition of potash should not be needful.

Where the surface soil contains a large proportion of chalk the grass responds well to sulphate of ammonia and superphosphate, but instances are familiar enough where all the calcareous material has been dissolved out of the upper layer, leaving it in a seriously acid condition. For general use on chalk soils, nothing better can be recommended than a well-balanced mixture of artificials containing suitable amounts of nitrogen, phosphates, and potash.

From the point of view of insects and other pests, chalk and limestone soils are apt to be rather troublesome. Those, for instance, who are engaged in the maintenance of turf on such land cannot fail to observe the number of worms present, and the regular use of a good worm destroyer is essential if the surface is to be kept free from mud. Leather jackets also abound, and in some seasons extensive damage is done by this pest.

Weeds, too, need frequent attention, owing, no doubt, to the extensive natural flora of calcareous soils. Legumes are abundant, the smaller clovers, trefoils and vetches causing a great deal of anxiety to the Greenkeeper. Milkwort, burnet, speedwell, geranium, and yarrow are other characteristic plants of chalk soils which occasionally appear in great numbers on a Golf Course.

Among the grasses, sheep's fescue is prominent, and in combination with allied species is responsible for the formation of an excellent sole of turf. Crested dogstail, smooth-stalked meadow grass, downy oat grass, yellow oat grass, upright brome, and false brome, are common chalk soil grasses of more or less value.

The study of the soil is far from complete, and fresh facts are constantly being added to the knowledge already possessed of the complex problems of fertility. The biological or micro-organic life of the soil, for example, is a discovery of quite recent years.

The question of soil acidity is receiving close attention and promises to be the subject of some interesting revelations. It is now scarcely sufficient to find out whether or not a soil is acid, but to ascertain as far as possible the relative degree.

There seems reason to believe that each plant has a preference for a certain degree of acidity or sweetness in the soil. This would appear to account for the liking that many plants have for one particular soil, and for their refusal to flourish on others. It would also explain why some grasses are injured by liberal dressings of lime, while others object to certain artificials solely on account of the acid medium they create in the soil. It also throws light on the important

question of competition among plants. To give you an example, may I remind you that many grasses will succeed on a wide range of soils when sown alone, but on some land they are reduced to a secondary position, or even crowded out altogether, as soon as other sorts are added; it is supposed that the degree of acidity or sweetnesss is directly favourable to the survivors.

In considering a scheme of manurial treatment for any given soil, some attention, therefore, ought to be paid to the natural acidity or sweetness of the land in relation to the type of vegetation it is desired to establish. Fortunately, through the efforts of eminent scientists, we are now in posssession of means, whereby, the exact state of the soil can be determined. The day of the red and blue litmus slips is long past, and now, among other methods there is a large choice of indicators that reveal all the fine degrees of acidity or alkalinity.

The effect of acidity on the type of grasses present is rather well exhibited in the case of some of the lighter soils, where generally speaking, the number of species is small. On the pure chalk soils of Southern England the degree of alkalinity is high, and hard fescue and crested dogstail flourish. Where the percentage of chalk diminishes, other grasses, such as sheep's fescue, and smooth-stalked meadow grass, make an appearance, and as the neutral point is reached the number may perhaps be increased by fine-leaved sheep's fescue and red fescue. Meanwhile hard fescue and crested dogstail may have disappeared.

Sweet vernal prefers a slight degree of acidity, and under those conditions the number of grasses may conceivably be reduced to that variety in company with fine-leaved sheep's fescue, red fescue, and Agrostis vulgaris, while an increase in acidity of the soil might result in red fescue and Agrostis vulgaris being the sole survivors. The appearance of brown bent (Agrostis canina) in the turf might be looked upon as indicating a further stage of acidity, and eventually the species flourishing might all be bent grasses. As the amount of acidity increases beyond the point favourable to bents, these would, no doubt, give way to mat grass, heath grass, and purple melic grass, and such in their turn, might be superseded by nothing more than a mere covering of mosses. All such changes, of course, would be very gradual in character.

Thus, for certain classes of turf a slight degree of alkalinity can be regarded as essential, and generally speaking this is the case with all fertile medium loams. But where red fescue, fine-leaved fescue, creeping fescue, or bent grasses predominate, slightly acid conditions seem to be helpful in restraining the growth of undersired species. The complete grass fertiliser of to-day, should undoubtedly possess a slight acidity in order to assist soil conditions in favour of the more valuable fine grasses. It would be equaly useful for application to classes of turf, seeing that dressings of lime would also be resorted to where needful.

Daddy Longlegs (Tipula oleracea).

By W. H. DREWITT, Greenkeeper, Burhill Golf Club.

THE flies commonly known by the name of Daddy Longlegs, or Crane-flies, which develop from the grubs known as "leather jackets," are to be seen in multitudes, especially in autumn, about most Golf Courses, where they deposit their eggs in the turf, which means endless worry and trouble to Greenkeepers, because of the enormous damage the grubs do by gnawing the grass plant just below the surface, and in most cases totally destroying the turf. The female Tipula oleracea lays her eggs mainly during autumn in the turf or on the surface, or on damp grass. These eggs are small, black, and shiny, so small and numerous that as many as three hundred or more are to be found in one female, forming a mass which occupies nearly the whole of the abdomen. The grubs which hatch from these eggs are cylindrical, legless, wrinkled across, of a dirty greyish or brown colour, the tint of which may vary considerably; when full grown they are about an inch to an inch-and-a-half long. From the great toughness of the skin the grubs are mostly known as leather-jackets. The grubs change to the chrysalis state under the turf, or under the protection of weeds. Besides the species known as Tipula oleracea, of which the tawny brownish appearance is well known, there is a smaller kind, of a yellow colour, spotted with black, known as T. masulosa, or Spotted Crane-fly, and another larger kind, known as T. paludosa, or the Marsh Crane-fly. These two kinds damage the turf in the same manner as the common Daddy Longlegs, and require the same methods of prevention.

PREVENTION AND REMEDIES.—The points to be especially attended to are:—(1) Any measures tending to lessen the quantity of eggs laid; (2) Methods which will destroy the egg or grub; (3) Special application of manure as may push on vigorous growth and carry it through the season, when it is suffering from part of the supplies being cut off.

(1) The parent fly frequents neglected rough grass and shady spots, such as are to be found on most Golf Courses. Mowing neglected spots and burning the grass and weeds would destroy a deal of shelter; and bush-harrowing the whole of the Course, the rough, under trees, etc., is a good plan to lessen egg laying, also to well brush the Greens every morning, as it disturbs the shelter in which the flies prefer to lay, and damages and exposes many of the eggs. Autumn top-dressing would encourage or deter attack, according to material used. Farm manure would only make agreeable shade or shelter for egg-laying purposes. Starlings are most useful in lessening the grubs, also wasps, and I have noticed rooks catch and swallow the flies at a rate of four a minute.

(2) Methods which will destroy the egg or grub. The grub is to be found most plentifully after a wet autumn, because this state of weather suits the flies, and because the continued wet does not allow the Greenkeeper to get the rough grass cleared up, or to give the Greens, etc., proper attention. I have found Daddy Longlegs grubs as early as November, destroying the turf. The regular work of destruction, however, usually commences later, and continues till the end of June, or even to the beginning of August. Much will depend upon the state of the weather, the character of the soil, and the condition of the turf at the date of attack, as to the amount of damage which the Greenkeeper will have to repair. The flies and grubs may be found throughout the summer, but for the most part the grubs change to the pupa state, in which they can do no further harm so far as eating is concerned, from July to September. Daddy Longlegs grubs are sometimes carried to Golf Courses in farm manure, and are also to be found in composts that are mixed with decaying turf. Such applications, therefore, need inspection where there is reason to suspect infestation, and most especially in the case of rotten turf heaps. The following are useful applications in case of attack of the grub: Napthalene, nitrate of soda, Kil-Jac, Tarbol, salt, soot, and Larvoid. A few experiments I have tried with the grub may interest you. With regard to want of food, some of the grubs I placed in a glass vessel with a little soil, but no turf, and they were perfectly healthy after three or four weeks. Under drought, however, as far as my experiment went, the grub rapidly fails. With regard to power of bearing immersion, I found that although the grubs appeared to be dead after remaining in water for about two days, yet that they recovered after being exposed to the air. The exact time at which life was destroyed after being replaced in water was difficult to tell, but the whole time they lived from the beginning of the experiment might be considered about four days and nights; it did not exceed five, for the grubs then burst

(3) Special applications of manure. I don't think it necessary for me to say anything on this question, as most Greenkeepers know what suits their particular soil best.

Methods of prevention and remedy of this infestation may be said to lie in carrying out, so far as can be done, the following principles:—

(1) Clearing away all rough grass and rubbish about the Course, especially round about the Greens, so as to prevent it serving as food and sheltering places.

(2) Giving the turf a good start as soon as possible, by special measures of good manuring; and

(3) In case of attack, although mechanical measures, as forking, spiking, etc., are of some service, mainly depending on such fertilising application as will be available at once to the turf, and keep up its strength by the extra supply of food.

Tractors.

By G. LEMM.

IT is only within the last two or three years that the tractor has come into its own in the routine work on the Golf Course, and even now there are some who steadfastly adhere to the horse as a means of power. While it must be admitted that a horse can do some work more satisfactorily than a tractor, when properly used the latter is a real time and labour saver.

The chief work of the tractor, of course, lies in the haulage of gang mowers, in which field it may be said to be almost indispensable to the efficient maintenance of Courses on heavy soils, for not only can the tractor pull a lower cut than a horse, but it does the job with such expedience that, if necessary (and, alas, it is too often the case in the growing season), the ground can be covered twice weekly.

The man in charge of the tractor has it in his hands to make the running costs low or otherwise, so that it pays to employ a driver who is thoroughly competent, and give him a good wage. Too often, when a tractor is acquired, an employee—no doubt an excellent worker at his own job—is given three or four days' tuition, and left to his own devices. Thus, during the most critical period of the machine's existence, that is when the bearing surfaces are "running in," it is driven without that care that comes of thorough understanding. Unless treated considerately for the first two or three weeks, the repair bill on any machinery is likely to be heavy, and this applies more forcibly to an engine running at fairly high revolutions, as is usually the case in a tractor.

None but the oil recommended by the makers of the tractor should be used. The best lubricant is cheapest in the long run. To my mind the perfect tractor for Golf Course work has yet to be evolved. Those in general use at present are merely adaptations.

A compact, light, yet substantial caterpillar, able to travel on the road, while being capable of pulling a load without injury to turf, is my idea of a perfect haulage unit for the links. The radiator must be of ample capacity to ensure adequate cooling. Continuous work and hill-climbing is apt to find this a weak point of some tractors at present in vogue.

G. LEMM, Assistant, Gerrards Cross G.C.

The Golf Greenkeepers' Association.

The Fifteenth Annual General Meeting was held at the Wansted Golf Club House, Wanstead, Essex, on Monday, 9th August, 1926.

Report of the Executive Committee.—The Executive Committee have pleasure in submitting to the Members the Fifteenth Annual Report and Statement of Accounts for the year ended 30th June, 1926.

Membership.—Forty-one new active Members have been elected during the year ended 30th June, 1926.

Accounts.—The Executive Committee are pleased to be able to report a balance on the year's working, and a total working balance of £110 12s. 2d.

The Committee are greatly indebted to the undermentioned for their continued financial support to the funds of the Association:—

Yorkshire Union of Golf Clubs, Frederick G. Hawtree, Neasden Golf Club, Shanklin and Sandown Golf Club, Oxhey Golf Club, Royal Liverpool Golf Club, Berkhampstead Golf Club, Mid-Surrey Golf Club, South Herts Golf Club, R.A.C. Golf Club, Cooden Beech Golf Club, Goodwood Golf Club, Muswell Hill Golf Club, Thorndon Park Golf Club, Croham Hurst Golf Club, Willingdon Golf Club, Sudbury Golf Club, Flackwell Heath Golf Club.

Golf Tournament.—The Annual Golf Tournament was held in August over the Worpledon Golf Course (by kind permission of the Worpledon Golf Club), and the Officers and Committee are greatly encouraged by the manner in which Members supported the competition (100 entries having been received), and the generous response to the appeal for prizes.

The Committee, Members, and all concerned with the management of the Association are greatly indebted to the Worplesdon Golf Club for the use of their splendid Course and Club House, and for their kind hospitality on the day of the competition.

Journal.—The Committee very much regret that, owing to unforeseen circumstances, they have been compelled to abandon the publication of the Journal till a later date. This will be receiving the immediate attention of the Committee, and they feel sure that they can safely promise that the Journal will be in the hands of the members by the early spring of 1927.

Lectures.—Lectures were given to members during the winter and early spring at the London Stone Hotel, Cannon Street, by Mr. Birch, of Messrs. James Carter and Co.; Mr. Watts, of Messrs. Sutton

and Sons; and Mr. F. G. Hawtree, of Messrs. Hawtree and J. H. Taylor, Ltd. The Lecturers and Committee were greatly encouraged by the way these were supported and appreciated, and hope to be able to make arrangements for the continuance of these during the winter months.

LIBRARY.—A Library, composed of books that are of great assistance and interest to members, has been instituted in the Association, from which members may borrow from time to time by applying to the Secretary and enclosing cost of postage.

EMPLOYMENT BUREAU.—The Executive Committee have much pleasure in reporting again that this branch of work has been of valuable assistance to Greenkeepers and Golf Clubs during the past year.

HON. AUDITOR.—The Committee wish to express their thanks and appreciation of the services of A. F. Stoy, Esq., F.C.A., for kindly acting as Hon. Auditor to the Association.

G.G.A. ARTISAN GOLF CLUB.—Twenty-six members joined the Association Artisan Golf Club during the past year. The Club is still affiliated to the Artisan Golfers' Association, and therefore members of the Club, on payment of 1s. annually, become eligible to qualify to compete in the Artisans' Championship and other competitions arranged by that Association from time to time.

In accordance with the ruling of the Artisan Golfers' Association, their Competition is divided into two section, viz., Senior and Junior. The Senior Section with Handicaps up to 9, and the Junior Section Handicaps 10 to 18. Two in each Section to qualify.

OBITUARY.

The Committee very much regret to have to report the deaths of Mr. George McNeice and Mr. W. Ball, both very old members of the Association. Mr. McNeice was held in very high esteem by the members, and was a very popular Chairman of the Association, having held that office since August, 1921, until his death on February 21st, following an operation; also Mr. W. Whitehead, Blackwell Golf Club, Bromsgrove, Worcester.

Signed on behalf of the Committee,

W. H. SMITHERS,

Hon. Secretary.

The Golf Greenkeepers' Association

ACCOUNTS FOR THE YEAR ENDED 30th JUNE, 1926

BALANCE SHEET, 30th June, 1926.

Liabilities.	£ s. d.	£ s. d.	£ s. d.
Sundry Creditors—			
Expenditure Accrued		9 5 0	
Annual Subscription paid in Advance ...		0 10 6	
			9 15 6
Accumulated Funds—			
Benevolent Fund as at 1st July, 1925 ...	29 9 2		
Add Interest on Deposit ...	0 14 1		
	30 3 3		
Less Grants ...	8 0 0		
		22 3 3	
General Account as at 1st July, 1925 ...	107 13 10		
Add Surplus as per Income & Expenditure Account for year ended 30th June, 1926 ...	2 18 4		
		110 12 2	
			132 15 5
			£142 10 11

Assets.	£ s. d.	£ s. d.
Cash with Bankers—		
Current Account	95 5 11	
Benevolent Fund Deposit Account	22 3 3	
		117 9 2
Library at Cost		5 1 9
Office Furniture as at 1st July, 1925	25 0 0	
Less Depreciation	5 0 0	
		20 0 0
		£142 10 11

INCOME AND EXPENDITURE ACCOUNT, 30th June, 1926.

EXPENDITURE.	£ s. d.	£ s. d.	INCOME.	£ s. d.
To Expenses, Northern Branch ...		10 10 0	By Entrance Fees (41 at 1/-)	2 1 0
,, Postages and Telegrams ...	17 11 4		,, Members' Subscriptions (191 at 10/6) ...	100 5 6
,, Printing and Stationery ...	19 6 4		,, Honorary Members' Subscriptions ...	25 14 0
,, General Expenses, including Advertising, Hire of Meeting Rooms, etc.	30 11 8		,, Artisan Golfers' Association Fees (26 at 1/-)	1 6 0
,, Clerical Assistance	23 3 0		,, Special Donations to Prize Fund ...	40 17 6
,, Officers' Travelling Expenses	19 5 4			
		109 17 8		
,, Subscription to Artisan Golfers' Association		1 5 0		
,, Prizes		40 13 0		
,, Depreciation—Office Furniture		5 0 0		
,, Balance, Surplus for year carried to Balance Sheet ...		2 18 4		
		£170 4 0		£170 4 0

I hereby certify that I have examined the above Accounts with the Books, Vouchers, and Banker's Certificate relating thereto, and I certify them to be correct.

A. F. STOY, Chartered Accountant, *Hon. Auditor*,
103, Cannon Street, London, E.C.4.
26th July, 1926.

(Signed) W. H. SMITHERS,
Hon. Treasurer.

Annual Golf Tournament.

Greenkeepers from all parts of the country, numbering about one hundred, assembled at the Wanstead Course, Essex, for their Annual Golf Tournament, on the 10th August, 1926.

A stroke competition over thirty-six holes was played for prizes aggregating £140 in value.

Amongst the various prizes competed for were:—May's Challenge Cup and Replica; Messrs. James Carter and Co.'s Gold Watch and Chain; H. Pattisson Trophy and Replica; James Carter and Co.'s Silver Watch and Chain; and "Golf Illustrated" Challenge Cup.

The early starters had to play through a drenching rain, but as the forenoon advanced the weather cleared beautifully, and the conditions in the afternoon were ideal for play.

W. Brook, of Woodbridge Golf Club, who captured the leading prize, was fortunate in being a late starter and escaped the violent thunderstorm which swept over the Course.

The prizewinners and their scores were:—

	H'cap	Net score.
*W. Brook, Woodbridge	18	141
†G. Bird, South Herts	8	150
‡J. McCourt, Chorlton-cum-Hardy ...	9	151
W. J. Mason, Hendon	9	152
R. Audley, Guildford	8	153
P. F. Everett, Beckenham	2	153
T. Dyke, Norbury	4	153
G. H. Fenn, Wanstead	9	154
H. Binstead, West Hill	20	154
S. J. Morton, Tidworth	6	154
R. Jacobs, Temple	6	154
A. Whitall, Worplesdon	18	155
C. Saunders, Goodwood	12	155
W. H. Smithers, Shirley Park ...	5	156
W. Harden, Epsom Downs ...	12	157
D. Ness, Chingford	6	157
E. Roberts, Berkhampsted ...	8	158
J. T. M'Donald, Swinley Forest ...	4	159
L. Grewe, St. Margaret's-at-Cliffe ...	6	160
J. T. Loach, Willesley Park ...	0	160
G. W. Smith, Thorpe Hall	3	160
C. R. Smith, Bramshot	12	160
J. Burningham, Roehampton ...	12	162
J. Dishart, Clacton-on-Sea ...	4	162
W. Bright, West Essex	2	162
J. Durie, Coombe Hill	24	162

E. Dunn, Woodcote Park ...	...	10	163
T. Bridges, Hoylake ...	...	8	163

* Winner of May's Challenge Cup and Replica, and James Carter and Co.'s Gold Watch and Chain.

† Winner of H. Pattisson Trophy and Replica, and James Carter and Co.'s Silver Watch and Chain.

‡ Winner of " Golf Illustrated " Challenge Cup.

Immediately after the competition the prizes were presented by James Derby, Esq., Captain of the Wanstead Golf Club (in the absence of Lord Riddell).

Thanks were accorded to the Wanstead Golf Club for extending the courtesy of the Course and Club House to the Association for the competition, and for entertaining the competitors to lunch and tea on the day of the competition. To the prize donors, to Mr. Frank Thomas (the Secretary), Mr. Gaudin, Professional, who acted as starter (in the drenching rain), Mr. Herbert Robinson and his staff, who attended to the cards, the Steward and his staff, and to all those who materially assisted in some way or other to make the competition so successful.

On the Wednesday following the competition, Messrs. Alex. Shanks and Son took the party for an outing by chars-a-bancs to Southend. The party were under the direction of Mr. "Sandy" Cuthbert, and were met on their arrival by Mr. Reid, the London manager of the firm. A visit was made to the new Municipal Course. This was followed by an excellent lunch, and afterwards a cruise in the " White Heather," motor-launch. Despite a few heavy showers, which fell during the day, the proceedings were altogether most enjoyable. The party arrived back at Wanstead in fairly good time.

Special Prizes.

P. F. Everett, best scratch score, 36-holes, Silver Cup, presented by Wanstead Golf Club.

W. H. Smithers, best scratch score, morning round, Silver Cup, presented by J. J. Esplen, Esq.

T. Dyke, best scratch score, afternoon round, Queen Anne Teapot, presented by A. Lacey.

G. Bird, " Artisan Gold Medal," presented by the " News of the World."

Trade Notes.

Members are urged to look at the advertisements in this Journal when they are in need of anything in the way of Golf Course requisites.

A glance through them will prove that all the firms which advertise in the "Golf Greenkeepers' Association Journal" are the best known in the golfing world, and their goods are absolutely reliable; in most cases they have been tried and proved satisfactory by some of the foremost Greenkeepers of the day.

Considerable strides have been made in connection with the upkeep of Golf Courses since the publication of the last "Journal." The horse on a Golf Course, pulling mowing machines, etc., will soon be a thing of the past; the Fordson and Metropolitan tractors are rapidly taking their places. No Golf Course should be without either of these, which are capable of hauling a septuple or a quintuple (i.e., 7 or 5 unit) mower over varying gradients.

These mowers are now on the market, in either the side-wheel or the light roller type, fitted up for haulage by either the above tractors referred to, and can be supplied by the various firms advertising in this "Journal."

It is not necessary for me to go into detail of the various advantages of these machines, as most Greenkeepers have already one or more of these at use on their Courses, and, from what I hear, wouldn't be without them, which speaks well for their future.

W. H. SMITHERS.

Lending Library.

The Executive desire to announce that a Lending Library has been started, from which members may conditionally borrow books on subjects appertaining to Greenkeeping.

The books available for borrowing at present are as follows, with the postage to be prepaid by the borrower as stated:—

"Fertilisers and Manures," by Sir A. D. Hall. ...	Postage	6d.
"Agricultural Botany," by John Percival, M.A., F.L.S.	,,	6d.
"Vegetable Mould and Earthworms," by C. Darwin	,,	6d.
"Fertilisers," by E. B. Voorhees.	,,	6d.
"Grass," by A. J. Macself.	,,	6d.
"Elements of Botany," by Sir Francis Darwin. ...	,,	4d.
"Weeds," by R. Lloyd Praeger.	,,	3d.
"Chemistry of the Garden," by H. Cousins. ...	,,	3d.
"Inorganic Chemistry," by E. C. C. Baly. ...	,,	3d.
"Botany," by Joseph W. Oliver and W. B. Grove ...	,,	3d.
"Chemistry," by W. A. Tilden.	,,	3d.
"Golf Architecture," by Dr. A. Mackenzie. ...	,,	3d.

It is hoped to add to this collection from time to time, and the Hon. Secretary will be glad to have particulars of books, the study of which may be useful to members.

The loan of a book may be had on application to the Hon Secretary. Potage must be prepaid in all cases, or applications may not be considered.

Readers must keep books clean and not injure or deface them in any way.

Notice to Members.

The Executive Committee wishes to make it known amongst its members that this copy of the "Journal" is sent to you gratis and post free, and that you are under an obligation to the Association not to lend this book to any individual whatever, no matter in what station of life he or she may be.

W. H. SMITHERS.

The Golf Greenkeepers' Association Employment Bureau.

Members out of employment or desirous of changing their situations should apply to the Hon. Secretary, who keeps a register of Golf Clubs in need of Greenkeepers.

JOHN YATES & Co., Ltd.,

ESTABLISHED 1804.

Suppliers of Golf-course Tools and Appliances of every Description.
Distribution Centre:

SCHOLEFIELD ST., BIRMINGHAM.

We make Sand Boxes, Hole Cases, Tee Plates, Hole Borers, Notice Plates, Flags, Ball Tubes, Mud Brushes, Tee Mats, Rollers, Barrows, Turf Spades, Shovels, and all Greenkeepers' Tools.