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of the

UNITED STATES GOLF ASSOCIATION GREEN SECTION

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The Construction Period in the History of a Golf Course

The usual history of golf courses may be divided for convenience into three major stages. The first stage is that of planning and organization, the second is the period of construction, and the third is the prolonged period of maintenance. Naturally, as in any generalized classification, there is often much overlapping in this order; but whether the dividing lines be distinct or indefinite, the fact remains that in the majority of cases this is the logical and actual sequence. Although these stages may be distinguishable in point of time and distinctive problems, there is of course a most decided interrelationship between them. Problems of the construction period are most profoundly influenced by the attainments of the period of planning, and likewise many of the most difficult problems of maintenance are greatly aggravated or diminished by the errors or wise provisions of plans and construction.

Disregarding the courses built for real estate developments or other ulterior motives, it may be safely asserted that the majority of golf courses are built to furnish the maximum enjoyment for their membership throughout the longest period of the year that the climate will permit, and with a minimum of expense consistent with the facilities that are provided. Reconstruction is usually expensive, and even if the item of extra expense is not in itself serious there is always more or less interference with play and full enjoyment of the course for a short time at best. It is therefore advisable to plan and build with the greatest of care in order to provide against any necessity for reconstruction. It is surprising to find how many of the difficulties of maintenance can be traced back to faulty plans or poor construction. Frequently the only solution is to tear up the troublesome area and to rebuild, and often at many times the expense that would have been necessary to do the work properly in the beginning.

The majority of the problems on which Green Section advice is sought are those concerning maintenance and planting. The present issue of THE BULLETIN is devoted to a consideration of the problems of the construction period. The Green Section at present is not equipped to render much assistance in planning a course and, although we fully recognize the importance of the initial phases of the work, we must for the present leave those problems to others. Many good golf-course architects are available who are fully competent to advise on all problems of planning. Unfortunately, there has been a tendency among many architects to pay too little attention to problems of construction and maintenance. An exceedingly well-designed hole from the standpoint of architecture may be an utter failure due to inability to maintain the requisite turf under the con-

ditions imposed by those particular plans. When an architect plans a building it may be a relatively simple construction problem to execute those plans in steel and stone. When a golf-course architect plans, it must be remembered that his plans are to be executed in living plants. Therefore some of the so-called "ideal holes" can not be placed on any and every course merely because they are successful under some special condition.

We will therefore assume that adequate plans have been made and that a club is interested in carrying those plans into effect. In many cases it is found distinctly advantageous to turn over the whole construction work to some individual or company competent to handle such work. Whether the club chooses to use its own force or to turn it over to a capable contractor, it is well to have some one in the club familiar with some of the principles involved in planting a course. A little information on this work may be of much aid in avoiding some future difficulties of maintenance and some of the unpleasantness that may be involved. With that object in mind this issue of THE BULLETIN is written.

It is obviously impossible to publish a bulletin which will contain specific directions for planting turf under every conceivable condition. It is, however, possible to point out some of the general considerations that apply under practically all conditions. Knowledge of the general requirements of plant growth may be of great assistance if one intelligently uses that knowledge to modify his conditions as much as possible to fulfill these requirements. Plants fortunately have no sharp lines in their range of soil, climatic, and water requirements. This allows for much leeway in planting and maintenance. The nearer the approach is made to the conditions ideal for plant growth the less will be the future difficulties of maintenance.

The principles involved in the culture of finer grasses are in a general way the same one place as another. Grasses that thrive in Florida demand practically the same plant food as grasses in Canada. A sandy soil in Canada would be handled much the same as a sandy soil in Florida. Clays are cultivated the same one place as another. What is said about fall planting in the North is true of the South. The fertilizers best adapted to grasses in the South are equally good in the North. Some properties will require assistance by either open or closed drains constructed to carry off the surplus water, and this phase is common regardless of region. Most courses need artificial irrigation in one form or another, whether North or South. Therefore the reader must select from the following what applies to his particular case, and when the reference obviously is to a region thousands of miles away it will be noticeable. "Ifs," "buts," and exceptions will probably be numerous, but will be necessary even in a simple treatment of this subject.

Planning a golf hole is about as difficult as playing it. It is a problem in itself. The hole should be difficult to play, but at the same time it should be fair. And above all things else, it should be completely visible.

Golf Course Construction

By Kenneth Welton

Golf course construction is often regarded as merely that process of taking soil from one place and piling it in another in such a manner that when it is finally smoothed out it will conform with the more or less definite plans of the course architect. Unfortunately, in many cases this is all that actually happens in construction work. Good golf course construction should be more than molding of earth into prescribed forms as specified by an architect. After the course takes form it must be covered with turf, and this turf must be maintained under the trying conditions of every-day play. In construction work every effort should therefore be made not only to provide the course with a thick covering of turf, but to make every possible provision for the welfare of that turf in the years to come.

The Aims of Good Construction

It must be remembered that the grass in turf on golf courses is often growing under extremely unnatural conditions. When any living thing is grown under unnatural conditions it is necessary to make allowances in the way of providing as nearly favorable environments as circumstances will permit, else difficulties will soon arise.

Grass, like animals, requires food, air, and water. Unlike animals, plants are unable to move about to alter their environment, and the necessaries for existence must therefore be provided where plants are placed. It is not sufficient to provide only one or two of the requirements, for if one is absent all others are of no avail. One frequently finds men struggling to keep turf alive by means of heavy applications of chemicals to provide food. They soon find that such applications are useless if, due to saturation of the soil, all air is excluded from the roots.

Food and water can be applied in proper amounts any time after the turf is established. On the other hand, it is a difficult and costly undertaking to provide for the removal of excess water and the aeration of the soil any time after the course is built. Soil conditions should be made as nearly perfect as possible before any seed is planted. To accomplish this it is necessary to understand some of the fundamental principles involved in soil structure and plant growth. In this discussion we can merely mention some of these elementary principles.

Soil, for convenience, is classified according to the fineness of its particles, ranging from the fine particles of clay to the coarse particles of sand or gravel. Also, soil contains decaying vegetable or animal material, which is commonly referred to as humus. There are also present in varying amounts a great variety of chemicals in the form of salts, alkalies, and acids. These chemicals furnish food for the plants. Soil also contains countless numbers of bacteria and other microscopic animal as well as plant life. These organisms as a rule are beneficial in breaking down dead organic material and in making plant foods available. Thus some of the organisms found in manure help to decompose it and improve the soil wherever it is applied. Other microscopic organisms may be harmful and cause

injuries to plant life. The ideal soil for plant growth is one containing the proper balance of all of the above ingredients, giving it a crumbly structure with plenty of air spaces between the particles of soil. There must also be the right amount of water present in the soil to make this ideal soil effective in turf production.

A well-drained soil will warm up more quickly in the spring and hence induce earlier germination of seed or growth of grass than a poorly drained soil, and the growth will continue later in the fall. Roughly speaking, it takes five times as much heat to raise a volume of water one degree than an equal amount of air-dry soil.

Soil water is of three kinds,—gravitational, capillary, and hygroscopic. When heavy rain or excessive irrigation soaks the soil the spaces between the particles of soil are filled with water and the air is driven from the soil. If there is adequate provision for drainage this extra water runs out of the soil due to the pull of gravity and is referred to as gravitational water. After the excess water has drained away, there still remains a film of water surrounding each particle of soil. This is known as capillary water, and it is this water from which plants draw their supply under favorable conditions. When soil is dried in the air it still retains a certain amount of moisture, which is known as hygroscopic water. This latter is not available for use of plants and is therefore not to be considered here. Peat, for instance, may have a high percentage of hygroscopic water which, although not available to the plants, is often referred to in a misleading way in recommendation of peat, based on its so-called high water-holding capacity.

The main source from which plants and soil organisms derive their supply of moisture is capillary water. It is in the capillary water that most of the plant foods derived from the soil are held in solution. It is the presence of capillary water which provides also for the circulation of air in the soil, the water simply surrounding the soil particles as a thin sheet, continuous when the particles are close together, but allowing for air spaces when the soil is more open. Oxygen in the soil is necessary for the roots, since there is an exchange of gases in plants similar in some repect to breathing in animals. Air also aids the beneficial organisms in their normal development in the soil. When the pore space in loam or clay soils is filled with water, as it is when gravitational or surface water is present, the capillary water which held the soil in crumbs is dispelled, with the result that the soil particles fall apart. No matter how mellow the soil may be, the soil particles or crumbs at once begin to puddle or pack. The longer the saturated condition exists, the more compact the soil becomes.

Gravitational water seeps down around the soil particles in an open soil, carrying away with it injurious salts as well as toxic materials developed from root decay or the decay of other organic matter. It also fills up the pore spaces in the soil and thus displaces the air; but as nature abhors a vacuum, fresh air naturally enters the soil again as the free water descends. The gravitational water replenishes the capillary water around each soil particle, and the fresh oxygen supply assists in making fresh plant food available.

It would naturally be inferred that water which will carry away harmful salts will also carry away soluble salts which are of value.

Doubtless much of the readily soluble fertilizing material used today is lost in this manner if applied in excessive amounts, or if the soil is too open in texture, such as very sandy soil. If, however, the soil structure is right, the plant roots quickly absorb much of these soluble fertilizing elements, and a great deal of the soluble plant food remains also in the capillary water. The general tendency of capillarity is to bring water to the surface from varying depths, the flow being always from soil where the water films are relatively thick towards soil in which the films are thinner. This action is comparable to that when a piece of blotting paper is dipped in ink. Hence as the top soil becomes dry, the soluble salts are brought into contact with the plant roots by being drawn to the surface in the capillary water. In this way the plant roots are able to select such soluble materials as they require as long as the materials are present; but the roots may reject to a certain extent injurious salts. In well-drained soils both injurious and needful salts are finally washed or drained away beyond the power of the capillary attraction to bring them to the roots. Everything considered, soils should therefore not be allowed to remain saturated with water too long, and if the soil can not get rid of surplus water by natural drainage, ditches or lines of tile should be provided to carry it off.

Equipment

Often in golf course construction it is not realized until too late how much more economical it would be to purchase or hire adequate equipment for the work. As an example, it may not be realized until the job is half over that a team and wagon might have been bought

Snatch team loading a wheel scraper.

and paid for had they, rather than a wheelbarrow, been used from the start. In other cases it would be far greater economy to employ tractors than horses, and in still other cases the greatest economy would be in the use of still heavier machinery, such as steam shovels.

It is important to decide at the outset just what machinery can be used to advantage. Man power, horse power, or machine power are all used more or less on golf course work. Man power on golf work is the most expensive, even as it is in most construction, farming, or manufacturing operations. A good many details of golf course

construction must, due to the type of construction, be performed by hand. Picking stone, grubbing roots, burning, hand grading, and raking, are all phases of the work which are done more or less with hand tools, such as shovels, axes, spades, and rakes. But modern construction methods lessen the need of hand work greatly, and even the hand tools used are more efficient; for example, small piles of field stones are more easily loaded with stone forks than by hand. When it comes to larger stones it is easier to load stone boats than wagons. Grub hoes and mattocks are useful in rooting fairways, but with the proper clearing methods much of this costly work may be avoided. The disk plow and the palmetto plow are both useful in rooting ground. The disk plow, which requires only a small tractor for operation, cuts roots as large as one's arm in two and partially pries them loose. The palmetto plow, which is composed of three or more knives which cut into the soil at intervals, has revolutionized the clearing of palmetto land, since it tears the roots enough to allow men to quickly grub the roots loose. The palmetto plow, however, requires at least a 5-ton tractor to pull it.

As stated, a good type of plow, especially for work in rooty fairways, is the disk plow. These disks come in various sizes, and should be kept sharp; they bolt to an attachment secured to the body of the tractor and can be raised or lowered by the operator. If the tractor is not required for more steady work, a disk plow is a handy thing to have on a scraper job. It stands by idle, not burning gas, until a few furrows of earth are required to be loosened up for the scrapers. It will plow a much bigger and deeper furrow than a team of horses can.

Similarly, in burning there are pulley devices and methods for piling stumps which save hand work. Hand grading should be greatly reduced in golf course work by the use of horse-drawn and tractor-drawn equipment. Fine, natural contours can be made on scraper fills, and disk and drag harrowing bring out long undulating natural contours. By properly working horse-drawn and tractor-drawn grading equipment very little hand work need be done, and this phase is important since hand grading is costly. Thorough cultivation with the smoothing harrow and cultipacker saves much hand raking.

Various equipment can be used in construction, and it is rather important from an economical standpoint to decide upon the manner in which the job as a whole is to be done, before it is commenced.

In moving earth, except for small lots, it is comparatively costly to load by hand. In building greens or in making other fills or excavations, it is far less expensive to move earth for distances up to 100 feet with slip scrapers and teams, or with ordinary small farm tractors and scrapers which are operated by drivers. For distances over 100 feet tractor scrapers can still be used economically on comparatively smooth land, but where the route of hauling is rough or muddy, wheel scrapers are better. For hauls up to several hundred yards, wheel scrapers are very efficient, especially if the soil in the cut is naturally loose or is kept so by being plowed ahead of the scrapers. However, as most courses will be maintained by tractor units for mowing, it is an exceptional job on which a tractor or two will not be economical. In using the ordinary wheel traction tractor (not caterpillar), large cleats or lugs will be required for work with scrapers, also for rough plowing with a gang plow.

Where tractors, instead of teams, can be employed for grading, the work is usually done much more economically. In construction, where tractors are used from the beginning of a job, and employed for clearing, plowing, and other fairway work, it is usually easy to make them pay for themselves and show a profit. If the architecture of the putting greens calls for large fills and extensive elevations, the job should be done with a steam shovel or gas excavator. In that case the shovel would probably be rented, although some golf course jobs have required enough shovel work to pay for one and then show thousands of dollars profit. If a steam shovel or gas excavator is used, either teams or tractors are required to pull the dump wagons. The tractors necessary on fill work are at the same time the best for plowing and other preliminary work, but are of little use on future maintenance work. The tractors most useful for golf course construction work with shovels are of the 2-ton caterpillar type. They pull dump wagons or carts and can work in soft ground, climb steep grades, and turn in small spaces.

A shovel and tractor job needs some planning, and the shrewdest planner will save the most money on construction.

Clearing the Land

In commencing the construction of a golf course the first consideration will be that of the clearing, a subject discussed in detail in the article "Clearing Land for Golf Purposes," on page 56 of THE BULLETIN for March, 1928. This refers not only to heavy timber, woods, or scrub, but also to rock ledges, boulders, fences, buildings, and any other obstructions which will interfere with grading or with cultivation of the soil. Clearing and working of cleared land may well be carried on at the same time.

Using Unbroken Sod Land

Sometimes pasture land on the golf course property is found to have an even surface and to possess a good tough sod which is entirely satisfactory for golf purposes without any treatment other than mowing or perhaps the removal of a few large stones. In other cases a little top-dressing to fill low areas will be sufficient to make old sod suitable for fairways. Wherever possible, such old turf should be preserved, for it takes much longer to grow tough turf than is ordinarily realized. In some portions that are slightly ridged or uneven it is possible to improve the old turf by cutting in various directions with a sharp disk harrow. The harrow should be set almost straight so that it will cut into the turf but will not turn it over. The turf should then be fertilized and rolled. On old Bermuda turf this treatment given in either the spring or fall growing season shows very noticeable results. In treating old turf on stiff clay soils an application of coarse sand in addition to this cutting will benefit the turf by opening or loosening the soil around its roots. Another condition frequently met with on light, sandy soil where it would not be advisable to plow, is that of very thin topsoils with poor subsoil. If such land were plowed the small amount of humus con-

tained in the surface soil would be buried and to a large extent lost to the grass. Such land would, of course, be benefited by applications of loam or compost; but this is usually too expensive a treatment for large areas. A cheaper method is to apply barnyard manure at the rate of from 20 to 30 tons per acre. By setting the disks in such cases at an angle the manure can be well incorporated into the soil.

Breaking the Land

When the land is cleared of obstructions, whether it has been in cultivated crops, grain, pasture, or waste, it should be plowed and disked as soon as possible. Plowing should be as deep as practical, but not deep enough to bring up too much subsoil. Continuous cultivation for several weeks before planting greatly improves the physical condition of the soil, increases bacterial action and decomposition of organic material, conserves soil moisture, helps to eliminate weeds, and aids in the final leveling work. If there is sufficient time it will be well worth while to plant some green-manure crop to be turned under before planting. If there is no time for growing a green-

Digging a wide, open ditch with a wheel scraper on the side of a low fairway in Florida. The fill is being used to raise the fairway and to build the green and tee.

manure crop, and if manure is available, it is well to disk in a liberal top-dressing of manure (20 to 50 tons per acre) several weeks before seeding to allow time for decomposition and mixing with the soil.

Grading

On land which has been cleared of timber there are bound to be holes of various sizes left where stumps have been removed. These should be filled, or otherwise they may be flooded and make further work difficult. These holes may often be used to advantage as places to bury stones.

On most courses the chief problems of grading will be around the greens, for it is there that the most extreme filling and excavating will be done. This part of the work usually raises the serious question as to where soil for the elevated portions can be obtained and where suitable topsoil may be secured. If there is likely to be any scarcity of topsoil, the best method is to stake out the full extent of all cuts and fills and then remove all topsoil from these areas. When the topsoil has been removed the cuts can be made for the traps, and

the earth from these may be used for filling. Where traps are shallow and can not provide sufficient soil for filling to bring greens up to the desired elevation, it is necessary to obtain earth from some other locality, frequently from open ditches or the so-called "borrow pits" located where they will not mar the landscape. It is well to insert a word of warning against an all-too-common habit of construction men,—that is, the removal of good topsoil from approaches or other areas of fairways which happen to be most convenient. It must be remembered that members of golf clubs demand good turf on the approaches as well as on greens, and it is not fair to rob these areas of all good topsoil. Rather than use topsoil from approaches or fairways it is better economy to go to the rough for it, even though the haul may be longer.

The same care in conserving topsoil about the greens should be used in constructing tees and bunkers or even in leveling the rougher portions of the fairway. This topsoil can be replaced when grading is finished, to provide a suitable layer for the seed bed.

Drainage and Water Systems

Soils that contain sufficient organic material or, in some cases, sufficient sand, to be normally mellow, but which on account of insufficient elevation or an impervious subsoil are kept in a saturated condition, will be greatly improved by removal of free water. In some cases this can be accomplished by open ditches, but usually on golf courses underground tiles are necessary. Soils vary so in texture, even soils of the same type, and possess such different water-holding capacities, that it is almost impossible to indicate the proper depth and placing of tile lines for all soils. A certain amount of experimenting must be done by each golf course to determine the drainage characteristics of its soil or soils. If soils are over-drained, they will require more water; and if this water is applied as frequently and in as large quantities as needed, there will be too great a leaching away of otherwise available plant food. Ordinarily a soil should be drained no more than is necessary to dry it in the spring as soon as naturally well-drained soils in the neighborhood become dry or to keep them tillable as late in the fall as such neighboring soils are tillable. Golf course properties should be drained during construction, so that all parts of the property may be worked alike and, as stated above, as early in the spring as naturally well-drained soils may be worked. Before golf course properties are worked over, planted, rolled, and tramped upon, the drainage required for the soil may be ascertained. Once the course has been played on, provided the plowed and tilled soil has been sufficiently drained, any areas of hard or impervious soil that develop should be improved in mechanical structure by the addition of organic material or sand, and in some cases both.

Drainage work should be completed before winter. If much drainage is required the advice of some one experienced in such work should be sought. A plan should be made of the drainage system so that a record will be available after the drains have long since been covered and forgotten. In preparing a map of the drainage system it is good policy to map the water system at the same time.

Often courses are built on land where only short lines of tile here and there are needed. Open ditches can usually be provided to take

care of the drainage without interfering with the play. Open drains on fairways should be dug at proper levels for the water they are to take care of, and the banks should be graded so gradually that the ditch appears natural and a part of the fairway. When an almost constant flow is to be expected in a ditch, it can not be kept in sod, and in such cases tile would have to be used unless the ditch could be kept in the rough or only allowed to cross the fairways at points which did not detract from the correct playing of the hole. On hilly or rolling land greens are often built in positions where they receive too much overwash or seepage. Lines of tile will in some cases have to supplant open ditches to catch this water before it reaches the green. In laying a tile drainage system it is best to do the work either in the summer or early fall. If the ditches are dug while the ground is saturated, as it is in the spring, the soil around the tiles gets puddled, due to digging and handling the soil from the trench while it is sticky. It may take several seasons of freezing and thawing to undo the damage and make the tiles function satisfactorily. It is economy in laying a large system of tile drainage on a golf course to do the work with a ditching machine.

The types of tile most often used for golf course drainage are the common porous or agricultural tile, vitrified tile, and cement tile. Since most of the soil water enters a tile drain between the joints, the type of tile used does not matter much as far as the water-absorbing capacity is concerned. Vitrified and cement tile are stronger and less likely to break under pressure from above or from the effects of soil heaving due to frost. It is therefore usually safer to employ vitrified or cement tile for draining putting greens and for shallow fairway drainage.

Three-inch tile is satisfactory for laterals up to 400 feet in length, but 4-inch tile should be used for laterals up to a length of 1,000 feet. The water-carrying capacity of tile varies as the square of the diameter of the bore or waterway. Sufficient allowance should therefore be made to take care of several laterals entering a main.

The distance between the joints of porous tile should be at least ¼ inch, and ⅛ inch for cement and vitrified tile; this will allow for expansion. The eye should never be trusted to carry a grade while laying tile; some kind of mechanical leveling device should be used. It is desirable to have a fall of at least 3 inches in every 100 feet. If the grade for 100 feet of drain is doubled, the water-carrying capacity of the tile is increased about one-third. The bottom of the trench in which the tile is to be laid should be well cleaned and the tile should be set firmly in cinders or crushed stone. In the fairways field stone may be used, but the top of a fill of large stone should be finished off with gravel, crushed stone, or cinders. The top of this fill of gravel, crushed stone, or cinders should be from 10 to 12 inches below the surface, so as to allow for a sufficient depth of soil. When laying tiles in sand it is best to lay strips of tar paper over the joints. The tiles should be well packed and firmly settled to prevent their shifting while being covered or after the line is in use.

The deeper the tile is laid the farther apart the laterals may be placed. Laterals should run into mains not at right angles, but with the drop or flow. When a sudden decreasing of grade is necessary which would check the flow, the juncture should be made by means of a stone-lined or cement catch-basin, the bottom of the basin being

at least a foot below the lower tile in order to collect sediment. Outlets of tile lines should be well protected to keep them from being broken loose, crushed, or plugged up. Some stone or cement work is usually necessary to protect outlets properly.

In fairways, 2½ to 3 feet is probably the best depth at which to lay tile, provided sufficient drop may be gained. At such a depth in clay soils the laterals would probably need to be from 20 to 30 feet apart. In sandy and muck soils laterals may be placed twice this distance apart.

In putting greens tile should be laid at a depth of 1½ to 2 feet in clay soil and 2 to 2½ feet in sandy soil. The laterals in clay soils should be from 15 to 20 feet apart, and in sandy soils from 30 to 40 feet. In draining putting greens it is well to have a fall of at least 1 inch in 20 feet. On putting greens the herringbone system of laying tile is most popular. In this system the main is laid through the lowest portion of the green and the laterals are staggered into the main; that is, no two opposite laterals enter the main at the same point. If the slope of the green is in one general direction, it is best to have the main run in that direction and the laterals enter at angles from each side. In order to guard against the crumbling in of the ditches or the sinking of the fill, it is advisable, in putting greens, to pack the tile with cinders alone, without using coarser material, to within 8 inches of the top in clay soils and 1 foot of the top in sandy soils. It is also a safeguard in putting greens of sandy soil to pack an inverted tough sod over each joint.

The water system should be installed when the land is torn up in process of grading. For details of the water system attention is invited to THE BULLETIN for July, 1928.

PREPARING THE SEED BED

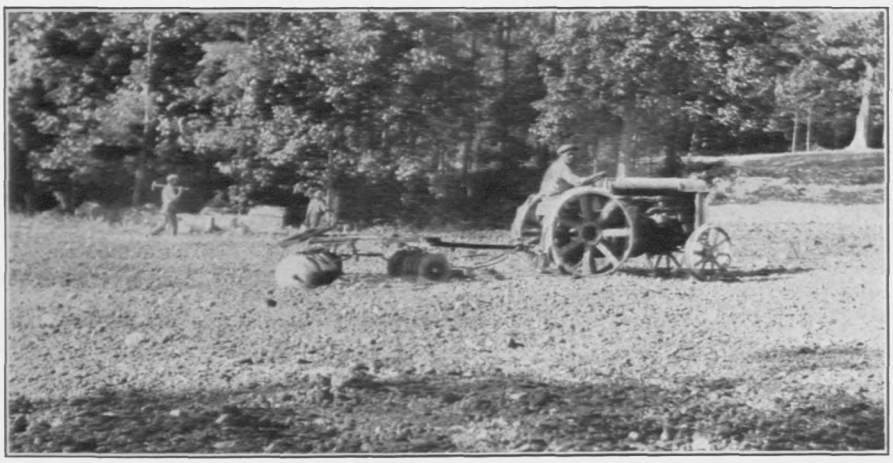
As before stated, it is well to plow as much land as necessary as soon as it can be conveniently worked. If land is broken in the spring, a spring planting of field peas or soy beans can be made in the North, or velvet beans in the South. This crop should be plowed under in the summer in time to let it settle a bit before seeding of the fairways is commenced. If a fairway is not to be seeded to grass in the fall it can be planted to hairy vetch and thus be provided with a green-manure crop to be plowed under in the spring. Land that has not been put under a green-manure crop should be cultivated during the summer.

After the topsoil has been replaced where necessary and all tile and water lines have been covered, the ground will be ready for its final preparation for sowing. When land that has had a green-manure crop plowed in has settled a bit, it, as well as the fallow land, should be disked and harrowed at frequent intervals up to the time of planting. The cultivation will not only keep out weeds and improve soil texture but will prepare a fine mulch for seeding, provided the land is not worked while wet. If fertilizers are to be used they should be worked into the soil before seeding.

Often in heavy soils the best way to open them up is to incorporate vegetable matter with the soil. Applications of strawy manures are best for this purpose. In applying manure to soil in preparation for golf turf there is no need to put the manure in deep. It is better to have it incorporated with the soil where it will do the most good.

The best way of accomplishing this is to spread the manure on the land after it has been plowed and cultivated, and harrow it into the soil. On some soils a spring-tooth harrow is better than a disk harrow for this purpose. In applying commercial fertilizers* it is advisable to work these into the soil only with the smoothing or spike-tooth harrow. These fertilizers are more or less soluble and are easily leached, and the young turf seedlings will receive more benefit from them if they are near the surface than if worked deep into the soil.

After the land has been plowed, disked, and harrowed, there will usually be some trash to clear away, such as roots, sticks, and stones. In picking up stones it is most economical to remove only those large enough to interfere with cultivation until the final working for seeding. This work should be carefully organized and supervised, since a few men sent out occasionally to pick up stones seldom do economical clean-up work. It is expensive to pick stones from a field and then



Cultivating fairways with the disk harrow.

disk, since other stones are turned up by the next disking. At times stones are so plentiful that their disposal becomes a serious problem. It is often found that where large quantities of stone are available they may be used to advantage in building foundations for greens or tees. In such cases these foundations are packed with small stone, gravel, or earth, and allowed to settle before good topsoil is added. Another use for stones is in drainage work.

Soil can be put into proper condition to receive seed by dragging with a smoothing harrow, cultipacker, brush drag, or other device calculated to make as fine a surface mulch as possible. It is not always necessary to hand-rake ground for seeding. Hand-raking of fairways just before seeding need seldom be done if the field is cleared of stone and trash and a proper mulch has been prepared by cultivation. However, if it is found necessary to rake the fairways before seeding, it is well to seed before the last raking so that the seed will have the benefit of being mixed with the soil by hand tools. Even if some piles of rubbish have accumulated during this raking it need not affect the seeding. A handful of seed can be thrown where rubbish has been piled.

* The rates of application of the various fairway fertilizers are contained in the table on page 112 of THE BULLETIN of June, 1928.

Turf Grasses

There are several more or less distinct regions favorable for certain grasses. The northern limits of the region in which Bermuda grass is the most extensively used fairway grass is, roughly, an imaginary line running from Washington, D. C., to Asheville, N. C., north through Kentucky to St. Louis, Mo., thence through the southeastern corner of Kansas, through the southeastern portion of Oklahoma, across the northern portion of Texas, and through the center of New Mexico and Arizona. The Bermuda grass belt includes most of southern California and the interior valley of the northern portion of the State. North of this line lies the section in which Kentucky bluegrass gains the ascendency. All along this line there are sections projecting for great distances from one territory into the other in which either Bermuda grass or Kentucky bluegrass encroaches. The line is also broad, since Kentucky bluegrass and Bermuda grass grow side by side over a range of sometimes a hundred miles in width. The southern limit of the Kentucky bluegrass territory is roughly the southern limit of the bents and fescues. Redtop and clover will thrive much farther south.

Throughout Florida and over an area extending up the eastern coastal plain to North Carolina, and from Florida west along the Gulf as far as Texas, lies the region in which carpet grass can be used. Throughout certain sections of New Jersey, the New England States, and the maritime provinces of Canada, Rhode Island bent frequently gives excellent results. In certain sections of the Northern States and in Canada some beautiful fescue fairways are found, but at the same time these Rhode Island bent and fescue sections will grow excellent Kentucky bluegrass.

Redtop may be mixed with bent for seeding putting greens. Redtop seed has been and still is very much cheaper than bent seed. Redtop germinates very quickly and produces a vigorous seedling which is of a very fine texture and practically identical with bent the first season. Redtop becomes coarser during the second growing season, but on putting greens it will not stand the continued close cutting and dies out before its coarseness has become objectionable. Bent will stand close cutting and, due to its tendency to spread and form a dense turf, will soon replace redtop. Redtop is used with bent on either putting greens or fairways for the purpose of economy, but with Kentucky bluegrass it is used for a dual reason. Redtop is usually more economical than bluegrass and will last several years in the fairway. On fairways redtop forms a good turf while it lasts; and as fairways are not cut as close as putting greens, in some sections it will remain for many years when mixed with other grasses.

Kentucky bluegrass requires about twice as long as redtop to germinate and it is seldom recommended for planting alone since it is not aggressive in the seedling stage. When sown with redtop the latter acts as a nurse crop until the second year. When the bluegrass has formed a substantial root system it will usually crowd out the redtop, due to its habit of spreading by rootstocks. Kentucky bluegrass is rather coarse for use as a turf on putting greens; still there are some clubs, where the soil is especially adapted to bluegrass, that have managed to keep it fine by frequent cutting, top-dressing, and fertilizing, so that it makes a fair putting surface.

There are several fescues that are used on golf courses. Chewings' fescue seed is produced in New Zealand and is easily obtainable. It is also notably pure. Genuine or creeping red fescue forms a more desirable turf than Chewings' fescue, due to its habit of spreading by slender creeping rootstalks. One should, however, be careful in purchasing red fescue seed since it is liable to contain much sheep's fescue seed and noxious weed seeds. Sheep's fescue is much coarser and more inclined to bunch than red fescue or Chewings' fescue, and its only use on golf courses is for the rough or on mounds and bunkers.

Several different kinds of bent are commonly used for seeding putting greens in the North. South German mixed bent contains a large percentage of Rhode Island or Colonial bent, a fair percentage of velvet bent, some creeping bent, and some redtop. Rhode Island bent is similar to Colonial bent. They are not creeping bents, but both make fine putting turf. Velvet bent is the finest in texture of the bent grasses. It produces an exceedingly fine, close-knit turf and is creeping in habit. Very little pure velvet bent seed is on the market, but velvet bent may be planted with stolons in the same manner as creeping bent, as will be described later.

Creeping bent has many different strains, and since some of these have a decided grain or are comparatively coarse for putting green purposes they are commonly established by planting with stolons rather than with seed.

Bermuda grass is used both on putting greens and fairways in the South. It is creeping in habit and vigorous in growth. Local strains usually make good fairways, but the finest possible strains should be chosen for the putting greens.

In purchasing seed of Bermuda grass it is well to get Arizona grown seed, since the Bermuda grown in that State is composed of strains which produce a comparatively fine turf. On very light sandy fairways it is often difficult to produce Bermuda turf from seed, unless water can be supplied plentifully. The young seedlings dry up in hot dry weather, since they are only rooted in the surface and have not a sufficient root system to procure moisture from deeper in the soil. In such cases old Bermuda sod can be torn apart and the runners or stolons planted in plow furrows, the furrows being 3 to 4 inches deep. The planters follow the plow, dropping stolons in the bottom of the trench, the stolons being covered as the next furrow is plowed.

Except in the southern part of Florida, Bermuda grass will turn brown and become dormant after the first frost, and it does not readily recover until the spring. On fairways where play is not so concentrated, the dead turf lasts fairly well during the winter and is helped out considerably with Japan clover and various winter weeds which appear at this season. However, the putting greens must be replanted to other grasses to form a winter turf. The old Bermuda turf should be skinned off to the surface soil, and the green top-dressed and seeded to Italian rye grass. Redtop, Kentucky bluegrass and fescue either alone or mixed, are also used for winter turf in the South, but both Kentucky bluegrass and fescue are rather too slow to germinate and to develop a turf, and redtop is subject to brown-patch injury in Florida. Mixtures of these grasses are frequently used, but it is doubtful if they have any advantage over the pure Italian rye grass, which is quick to germinate and forms a good turf in the seedling stage.

Carpet grass makes a tougher and better looking winter turf than Bermuda; it also keeps out weeds, particularly sand spur, which in time tends to ruin Bermuda turf. But even in its native regions carpet grass will not thrive on the variety of soils and locations that Bermuda will. Also it is very slow-growing and requires a nurse crop the first year. Consequently it is well to sow a mixture of Bermuda and carpet grass. If the location is suitable the carpet grass will crowd out the Bermuda grass after several years.

The accompanying rates-of-seeding table is intended for ready reference. It should be understood that in most cases the rates of seeding are quite flexible. Experience, however, seems to indicate that the rates suggested in the table are safe and economical to follow.

RATES OF SEEDING FINE TURF GRASSES

	Putting Greens	Fairways	Rough, Mounds, Backs of Bunkers	Winter Greens	Lawns
	Per 1,000 sq. ft.	Per acre	Per acre	Per 1,000 sq. ft.	Per 1,000 sq. ft.
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
All bents (for economy, 2 parts* redtop, 3 parts bent)	3– 5	.....	.....	..	3
Redtop	3– 5	.....	.....	5	3
Kentucky bluegrass	12–15	175–200	.....	15	10
Rough-stalked bluegrass (*Poa trivialis*)	12–15	.....	.....	..	10
Red fescue	10–15	175–200	.....	..	8
Chewings' fescue	10–15	175–200	.....	..	8
Sheep's fescue	.....	.....	40–60	..	...
Italian rye grass	.....	.....	.....	15	...
Annual bluegrass (*Poa annua*)	12–15	.....	.....	..	...
Dutch or white clover	.....	.....	.....	..	2–3
Bermuda grass	5– 7	50– 75	.....	..	4–5
Carpet grass	.....	50– 75	.....	..	4–5
One part redtop, 4 parts Kentucky bluegrass	8–10	125–150	.....	..	5–7
One part South German bent, 4 parts Chewings' fescue or red fescue	.....	125–150	.....	..	...
One part redtop, 4 parts Chewings' fescue or red fescue	.....	125–150	.....	..	5–7
One part redtop, 4 parts rough-stalked bluegrass	10	.....	.....	..	5–7
One part redtop, 1 part Kentucky bluegrass, 1 part meadow fescue	.....	130–160	.....	..	...
One part Bermuda grass, 1 part carpet grass	.....	50– 75	.....	..	4–5
One part redtop, 4 parts Italian rye grass	.....	.....	.....	10	...
One part redtop, 2 parts Italian rye grass, 2 parts Kentucky bluegrass	.....	.....	.....	10	...
One part Canada bluegrass, 1 part sheep's fescue	.....	.....	50–60	..	...
One part sweet vernal grass, 1 part Canada bluegrass, 1 part sheep's fescue	.....	.....	40–50	..	...
Vegetative planting. Creeping bent or velvet bent	One square foot of nursery turf will plant 10 square feet of putting surface.				

* By "parts" are meant parts by weight.

PLANTING

Seeding.—It is poor practice to seed in the spring under almost any condition. Seedlings do not develop quickly enough to crowd out the weeds, which are most active in the spring. Even in cases where the seed bed has been prepared in the fall ready for seeding at the earliest opportunity in the spring, it is rarely that the fairways are fit to play on until the following spring. Sometimes hot, dry summers kill a large percentage of the tender seedlings, as the seedlings have not had sufficient time to develop a root system before the advent of hot weather. In any event they are more or less easily affected by dry spells and usually make little growth the first summer. By seeding in the late summer or early fall the seedlings become established before winter; also in the preparation of the seed bed most of the weeds are destroyed. In the early spring the young grass develops an adequate root system and makes use of the ideal growing weather, and has a good chance of smothering out any weeds left over from the preceding year. By the first of June after early fall seeding, courses are often opened and provided with excellent fairways.

The reason for comparatively heavy seedings on golf courses is that a dense turf is required. Apart from the fact that the more seed used up to a certain point will give a thicker catch, is the fact that by using more seed a better distribution of the seed is usually accomplished. The more carefully the seed is distributed the less will be required to produce good turf. Also the finer the soil in the seed bed is prepared the greater will be the percentage of seed that under otherwise similar conditions, will germinate. On fairways of a clay or silt nature it may be necessary to break down the lumpy surface by frequent applications of the smoothing harrow with a light rolling in between. Also on fairways a plank drag will rub and crumble lumps without the danger of compacting the surface by too heavy rolling. The seed bed should be prepared when the soil is in a comparatively dry condition. Skilled workmen can distribute seed evenly by hand sowing. When hand sowing of fairways is done it is economical and good practice to distribute the bags of seed required for one fairway around or through the fairway so that there will be an additional check on whether or not the seed is being applied at the calculated rate. A gang of five men who actually sow the seed is found to be efficient. It is not easy to sow in a heavy wind, but a faint breeze is sometimes helpful. First it should be found from practice about how wide a space each man can evenly broadcast the seed over while walking. The five men should then commence at one side from five poles placed at the correct intervals; they then head for five poles or markers on the opposite side of the piece to be sown. This keeps the sowers in a straight course as they walk. After they leave the markers at one side of the field, a man placed there for the purpose moves the markers into the positions to which the sowers should walk on their return trip. Their seed pails should be refilled at each or either side of the area being seeded so as to remove the possibility of skipping some of the ground to be seeded. There are several fine mechanical seeders on the market, and when seeders are used probably only two or three would be operated. In either hand sowing or mechanical seeding it is desirable to sow half of the required seed when seeding across the fairway and the other half when seeding lengthwise. When seeding lengthwise with the fairway the fairway should be divided

into sections so that the sowers are not required to walk towards a point so far distant that they can not keep their course.

After the seed has been sown it should be mixed with the top half-inch of soil, and not deeper. This may be done on heavier soils by a smoothing harrow, provided the spikes are set at an angle, so that they will not dig too deep. On lighter soils which have been prepared so that they have a very fine mulch, a brush harrow is often used to distribute the seed through the surface soil. Brush harrows are made by laying bundles of fine switches between planks. A clevis is balanced in the center so that the team will pull the harrow evenly. When dragging to mix the seed in the surface soil, it is usually best to use a team of horses. The drag will partially eradicate their hoof prints. If tractors are used the wheels are liable to pack the soil so tight that sufficient mulch is not left in which to mix the seed. The horses should have their hoofs wrapped in bagging to prevent deep imprints.

After the seed has been harrowed or brushed into the surface mulch, a light roller should be passed over the seeded area.

Backs and sides of greens and tees should be seeded with the fairway mixture. Bunkers also are usually seeded with this mixture, although some clubs prefer to use the seed for the rough on mounds in order to give the earthwork a rugged, natural appearance. On mounds it is usually necessary to apply some topsoil as a germinating layer before seeding. After seeding, the mound should be tamped with the backs of shovels, if the grade is too steep for a roller, so that the seed will be less liable to be washed or blown away.

As the rough should be seeded with a different mixture from that used on the fairways, it will be seeded separately.

After seeding in the early fall it will be quite likely that the grass will need to be mowed once at least before it becomes dormant during the winter. The mower used should be sharp enough not to pull the grass seedlings while cutting. As soon as the ground becomes dry enough in the spring the seeded areas should be rolled. On stony fairways no doubt many stones will appear at the surface the following spring, due to frost heaving, and these should be hand-picked or raked off before spring rolling and mowing commence. The rolling should be done after the ground has commenced to dry out, and the roller should be heavy enough only to press the turf firmly down to the soil. After mowing is once begun the grass should never be allowed to become long or coarse. An application of fertilizer in the spring or fall is of more value on either a young or an old fairway than is an application of seed.

When areas of fairway need special attention on account of bare spots caused by washouts or pockets of poor soil, it is usually money wasted to reseed without special preparation being given to these areas. Manure or other organic matter should first be incorporated in the surface soil or a top-dressing of good soil should be applied.

Vegetative Planting.—When planting creeping bent or velvet bent by the vegetative method, one square foot of turf from the nursery row will provide sufficient stolons to plant 10 square feet. The stolons should be shredded and chopped or cut into pieces of from 2 to 3 inches in length. The putting green surface should be prepared as for seeding and the stolons distributed evenly. About one-third inch of sifted compost is then spread on the stolons by means of hand

sifters. With this amount of sifted compost the stolons will not be completely covered and many of the stolons will protrude above the surface. It is not wise to bury the stolons deeper. A light roller should then be passed over the planted area. The stolons must be kept damp by frequent watering, using a fine spray.

After the stolons have sent up blades to a height of 1½ to 2 inches they should be mowed down as close as possible with a sharp mower. The clippings from the first cutting should be left on the green, and another top-dressing similar to the one used while planting should be applied. From that time on the new green should be mowed regularly with the blades set at putting green length. The first clippings were left on the green, since where there is a node in any clipping a new shoot is likely to develop; but after the first few mowings of the green the clippings should be removed.

Spreading sifted earth over stolons in the vegetative planting of creeping bent. The superintendent stands nearby to see that the stolons are covered to the proper depth.

When fairways are planted by the vegetative method, the top-dressing is usually applied to the stolons with a mechanical soil spreader. However, good results have also been obtained by lightly pressing the stolons into the turf with a disk harrow set so that it will not turn the soil over. In both methods of planting, the rolling, watering, and mowing should follow as with plantings on greens and tees.

SODDING

If the grades on the course are sufficiently easy, seeding may be done on backs of greens, slopes into traps, or grades from tees, but if the grades are steep it will be found that sodding is the quicker method of getting a turf. Also areas frequently wash out, and as it is sometimes very difficult to get a catch of grass from seed on such places, sodding is resorted to. Where dead turf or weedy patches are removed on greens or tees sodding is frequently found to be the quickest manner in which to replace the turf. For this reason it is

well to have sod available that has been prepared in advance so that it is fit to replace turf on putting greens, tees, or fairways.

When laying sod the surface soil is prepared as for seeding except that it is made compact enough while dry so that footprints will not be readily made. It has been generally found that sods cut about one inch thick are convenient to lift and lay, and that since the roots spread out and take hold more quickly at that depth the sod will attach itself to its new seed bed much more quickly than when lifted with more earth. Before lifting sod it should be mowed close so that it will not need to be mowed soon after relaying, since it is more difficult to mow immediately after transplanting than before. The sod

Trimming sod to an even thickness by using a cutting box.

should be cut in true squares which will fit together well and should be trimmed to a uniform thickness before being layed. The cutting box is simply a table on which there are two sides or guides of a certain height, generally about 1¼ inches. There is a back of the same height. The sod is laid grass down on the table and a sharp blade, similar to a drawknife, is drawn over the sides of the table or box. As the sod is held by the back stop, the knife will cut through the earth and fine roots and will leave the sod an even thickness. When laying the sods or turfs they should be placed close together but not crowded or bulged. It is well to go over the sodded area and gently pat each sod with the back of a flat spade or shovel. The job should be carefully examined, and if the sods sink at the corners they should be brought level by having some loose soil placed under the low spot. Also bulged or raised corners that will not easily pat down should have sufficient soil removed to enable the sod to lie level. The sod

should then be top-dressed with a sandy loam top-dressing. The dressing need not be heavy, but should be brushed or rubbed to fill in the spaces between the sods. The area should then be sprinkled until the water has gone through the sod into the soil below, followed a day later, or more if necessary, by a comparatively heavy rolling when the sod has commenced to dry out. A roller weighing from 150 to 200 pounds per foot of roller is sufficient. The sod should not be allowed to become dried out for lack of watering before the roots have had a chance to take hold in the soil below.

Special Problems of Fairway and Rough

On fairways there are two areas in particular that require special attention while the course is being constructed. These are the approach area and the area lying between 150 and 250 yards from the tee. On par-5 holes there is also another area, lying between 350 and 450 yards, which receives an increased amount of wear. These areas receiving the bulk of the fairway play should be the first to receive special consideration after the greens and tees. Often during the construction of the green the approach is subject to heavy trampling and the ground becomes puddled. In some cases also the topsoil may even be stripped from the approach in order to improve the green. Turf on all such areas should be provided with a fairly deep and fertile soil, even if suitable soil must be hauled and spread on the areas. The approach should be particularly well graded. It is very disconcerting to a player who intentionally plays to a certain point before the green on his approach shot, to have his ball drop dead one time, bound over the green another time, or kick off to one side, due to uneven, poor turf. Often courses have an abundance of good soil in their rough and many poor approaches almost bare of topsoil. If topsoil is wanted, it is logical to take it from the rough, where it is not needed. By plowing and otherwise working the rough along with the fairways the rough is graded and the topsoil prepared for use during construction. Later, as it is required, it can be hauled away, and on some courses it furnishes an almost inexhaustible supply of soil for compost piles. On holes where the first hundred yards of fairway is to be treated as rough, there is no reason why the topsoil from these areas should not also be used. A rough with a dense, tangled growth is not desirable, and having at least an ounce of pity for the unfortunates who play most of their game there, would it not be a kindness to impoverish the rough so that it will sustain only a sparse, bunchy, open growth? Such a growth gives the required penalty by being difficult to play from, but, being open, the ball can not hide itself with its usual unerring instinct. Clubs also require much topsoil for the construction of greens and tees and for building compost piles for the future maintenance of the course.

Another area frequently neglected though one that does not receive much play, is that area behind and around the sides of the putting green. The rough does not necessarily continue around the sides and back of the putting green. Architects often do not insist on the preparation of this strip of fairway, which should extend around and behind the green for various distances, depending on the length and type of hole. There is no reason why a bold shot that runs over the green should have to be played out of the rough when a weak, overcautious shot short of the green sometimes gets the advantage of a

perfect lie on a well-kept approach. Frequently when the greens and fairways are seeded the areas behind the greens get only a last-minute clean-up before the job is pronounced finished. Such areas are not properly graded, the soil is often puddled, or the topsoil has been robbed from them, and they do not produce good turf. Often they are neglected by the greenkeeper, and are sometimes left to remain as the worst kind of rough. Also, in greens set back in woods, sufficient room is seldom left in the clearing to get either the fairway mower or hay mower back of the greens. The fairway mower ought to be able easily to include the area around the sides and back of the green along with the approach and the remainder of the fairway.

Special Problems of Putting Greens

There is no place on the course where play is as concentrated as on the greens and tees. But on greens this concentration of play, apart from removal of divots, is liable to do more damage than on tees, since the turf is kept cut unnaturally close. The root system is therefore correspondingly limited in its growth due to the natural habit of grass. Also greens are frequently placed in poorly drained and aerated positions, or on very poor soil, in order to procure a better golf hole from an architectural point of view. Therefore since special demands are made of greens special treatment is required.

Frequently architects choose very natural locations for putting greens. These locations seldom require any fill but frequently require some leveling. Before the leveling commences all topsoil should be removed, as this soil is usually needed. Few courses can afford to bury topsoil, since even if it is poor it is of more fertilizing value than subsoil and can be greatly improved by cultural methods or by being composted.

Before the green is shaped and graded its subdrainage should be studied as well as the likelihood of its being subject to surface wash or to seepage from the surrounding area. Surface water from surrounding hills may be kept from the surface of the green by grassy hollows and by sand traps. These traps and hollows should be made to conform to the correct architecture of the hole. If the green is cut into the side of a hill or is nestled against the hill with the foot of the hill as its back or side, the construction of the open ditch or grassy hollow is no simple matter. There is a tendency to construct such ditches altogether out of proportion to the natural landscape. Often these ditches built to catch wash from slopes are built deep with steep sides; they look out of place and artificial and are difficult to mow and hard to play from. If these ditches and hollows are built while the green is being graded much better results may be accomplished.

The top layer and planting of a green built without any fill work will be the same as with greens built with a fill and will be described later. Most putting greens these days are elevated from the surrounding terrain; this is not always done for drainage purposes, but is more often done by architects chiefly to give the modern golfers what they demand. Courses must be made easier to play than the natural lay of the land frequently provides. Courses are being built according to modern ideas, and modern ideas require that the breaks of the game, or the element of luck, must be reduced to the minimum. A putting surface sloping away from the play would be subjected to

most bitter criticism, even though in the old days of golf, when golfers played on what nature provided, such a hole would have been considered "fair to one, fair to all." Golf has developed into a more scientific game. Every shot coming within a certain range of perfection must get its reward. This requires that the architect usually must move much dirt to take the element of luck out of natural topography. Therefore putting greens are frequently found raised at the rear 10 feet or more above the natural topographical elevation. These greens require many hundreds of yards of fill.

Economy in golf course construction is still important enough to demand that the fill used in elevating greens be what can be obtained on the property and without the expense of physical improvement. Therefore we find fills of blue clay, silt, sand, peat, and all soil textures in between.

The topsoil should be of about the same physical structure on any green no matter what kind of fill is used. The topsoil is the layer in which the roots of the grass work. It is the layer in which roots get moisture and plant food for the turf. This layer must be of an open, friable structure, so that the roots may spread unhampered in any direction. The topsoil should be porous enough to allow for the easy absorption and drainage of water. If it is porous it will also allow for the air circulation through the soil, which is necessary for plant growth. A sandy loam is ideal. Loam consists of sand, silt, and clay in certain proportions. Topsoil should contain at least 10 per cent organic material and 30 per cent sand, and the balance may be clay or silt.

Topsoils are sometimes prepared by the acre on areas of good soil on the property, by plowing in manure, sand, humus, green crops, or whatever the soil requires to bring it to the composition described above. The soil is then hauled to the green and evenly distributed. It is less costly, however, to use the topsoil stripped from the putting green area, from traps areas, or from areas near the green. This material should be laid evenly on the finished fill and given the proper attention. On either heavy clays or silts or on light loams or sand, from 10 to 50 tons of manure should be disked into the topsoil. The amount of manure required depends on the organic content of the soil. The organic matter in the soil retains moisture and provides plant food as it decomposes. Also the particles of humus separate the particles of clay or silt and make the soil more crumbly or open in texture. In sandy soils decayed organic matter helps to bind sand particles together and provides a medium for the storage of moisture and plant food. When there is little time to prepare topsoil it is best to use well-rotted manure, since it has practically finished heating and decomposition is well on the way, and most of the weed seeds in it have been destroyed. However, fresh manure is probably more beneficial in improving the fertility and physical properties of soils, since it stimulates more bacterial action due to its rapid heating and disintegration. Fresh manure usually causes some decomposition and breaking down in the surrounding soil. Since fresh manure averages higher in moisture content than well-rotted manure, it should be used in applications 10 to 25 per cent heavier than well-rotted manure in order to add the same amount of organic matter to the soil.

After the organic content is right, sand should be added to clay or silt soils in sufficient quantities to bring the soil to a texture that

will crumble when released, after being squeezed in the hand when damp.

Peat or humus soils should be limed liberally, to counteract a probable toxic condition, and cultivated before being used as a putting green surface. Also they should have fresh manure worked into them to help bacterial action, and finally should have sharp sand added in sufficient quantities to give them at least 30 per cent of this material. When manure is scarce, peat, peat moss, or humus may be used as a substitute, to assist in improving the physical character of sands, clays, and silts. In the case of peat and humus, these materials should be limed, manured, and aerated by cultivation before use. Peat, humus, and peat moss should never be laid in layers but should be thoroughly mixed with the topsoil.

Layers of cinders, manure, peat, humus, peat moss, sand, clay, or any other material should never be placed in putting greens. Layers of different materials interfere with the capillary movement of water in soils, hinder natural soil drainage, and are not conducive to perfect root development. On sandy soils a comparatively deep layer of well-prepared topsoil should be provided. On clay, silt, or muck fills, a prepared topsoil of from 4 to 6 inches is sufficient. However, in greens built with these last mentioned soils as fills, tile drainage is usually advisable. A more or less impervious layer beneath the porous topsoil is liable under certain conditions to prove very harmful to the green, and when there is any fear of the subsoil developing an impervious character it is wise to tile-drain. Also when building a putting green with a close-textured soil care must be taken to have a grade of at least 6 inches in 50 feet on the top of the fill; that is, the fill or subsoil of the green should slope evenly off the green. This grade will assist in carrying off free water that seeps through the porous topsoil to the fill. It is a great mistake to leave hollows on an impervious fill, since if the tile drainage is not perfect toxic materials may accumulate in these pockets under the topsoil.

When greens are built on side hills or at the bottom of a long slope, it is necessary to protect the green from surface wash. Sand traps conveniently placed can be made to catch this wash. If, however, a sand trap can not be employed for this purpose, a grassy hollow which will deflect the water from the green should be constructed. Attempts to make an open ditch or grassy hollow on the hillside of a green often result in very artificial-looking atrocities when done, in a small way, by hand. Much more natural contours can be gained by doing the work with a team. A few furrows should first be plowed along the hillside where the open ditch is to be built, always plowing in the same direction, with the furrow turned downhill. This plowing should be repeated over the same ground, gradually going deeper into the hillside and higher up the hill. By gradually accumulating earth towards the bottom of the slope a terrace will be built. This should be continued by plowing the center of the terrace deeper and shoving the earth towards the side of the terrace nearest the green. This will give in a rough way an open ditch on the hillside above the green. The ditch will appear quite natural, as all the grades will be long. The ditch will perhaps be only 6 inches to one foot deep in the center; but as it should be constructed to run the collected wash down the hill and around the green at a fairly steep grade, this water will be carried away before it has a chance to

accumulate. The disk and drag harrows may be used to finish off this ditch, and since its construction has all been by team the cost will not amount to that of a ditch dug by hand, which invariably appears much more artificial.

It is generally necessary and always safe to guard against seepage into the green from higher ground. Seepage water is usually cut off from the green by laying a line of tile off the green on the hillside. The ditch should be dug deep enough so that the elevation of the bottom of the trench is no higher than the lowest part of the putting surface on the green. After laying the tile the ditch should be filled to within 6 inches of the top with field stone and rubble. The top of the stone fill should be packed with cinders or gravel, and allowance should be made for considerable settlement, since often these ditches will be 6 to 8 feet deep or even more. In ditches more than several feet deep the tile should be well laid and packed with large stone so that it is guarded from the concentrated weight of the stones above. Concrete or vitrified tile should be used, as it is stronger than porous tile.

If the green has been protected from surface wash and seepage from the higher ground, and the grade on the green is sufficient to carry off surface water, leaving no pockets in which water may accumulate, it may not be necessary to underdrain the green. However, if the subsoil is of a very compact nature which is likely to become almost impervious to the free rise and fall of soil water, the green should be tiled.

Before the green is planted all stones of a size that would interfere with the placing of the hole cup in the green should be removed to a depth of 6 inches. This should be done by hand-picking and raking while the putting green surface is being prepared. Frequently a layer of sifted soil is distributed over the green before seeding, but if the surface soil has been brought to a fine, mellow consistency, no sifted soil would be required. The surface should be lightly rolled to make it even and at the same time compact enough so that men in stocking feet will not leave deep imprints. The surface should then be hand-raked lightly, and dragged with a steel door-mat to remove small lumps and pebbles. The seed should be sown in two directions, as explained in the sowing of the fairways, by one or two careful men. The sowing should be followed by lightly raking the seed into the top half inch of soil, having the men drag their rakes in long, gentle strokes to avoid the ridging which results from raking with short strokes. The raking in of the seed should be followed by a light rolling to make the surface mulch compact around the seed. The seeded green should then be watered with a fine spray. The watering should be sufficient only to keep the germinating layer from becoming dry and not heavy enough to keep the surface soil constantly saturated.

Mowing should be commenced on seeded greens as soon as the seedlings have reached a height of about two inches. The mower should be very sharp so as not to pull the seedlings while cutting. The mower should also be adjusted so as to cut at a height of about one inch for the first cutting, but the mower should be lowered on each succeeding cutting until the grass is down to putting green length. Clippings should be removed from the first on seeded greens.

Special Problems of Tees

As various improvements have been made in playing the game, short and long tees have come more in demand. The changing from one set to another materially affects the playing of the course from the architect's standpoint and also lends an added interest to the game to the regular players on the course. Moreover, two or more tees to a hole are of great help to the greenkeeper, since they afford him opportunity to do needed repair work to one tee or set of tees while the others are in use.

The teeing surface has not only been increased by the system of building two or more tees to a hole, but the surface of the individual tees has been increased. Tees elevated high above the fairway and with steep banks add greatly to the cost of maintenance. However, with increased teeing space has come a more sensible mode of construction, resulting in gradual slopes which can be mowed with fairway units.

Some holes can be greatly improved by elevating the tees so as to bring into view landing areas or greens which the player on the tee otherwise would be unable to see. Except for such cases it however improves the landscape to build the tees so as to conform with the natural topography. It is easy to make the elevated tee less conspicuous by carrying a long grade away from its surface so that it may blend more closely with the surrounding landscape. When tees may be built practically flat on the ground, so much the better. An elevation of a foot or so from the surrounding ground is usually advisable to give the tee increased drainage, which is necessary since play is concentrated on it. When tees are built low and with long slopes running from them they may be easily mowed with the fairway mowers at the same time as the fairways, or if built in positions where the fairway mowers can not reach them it is easier to mow a slight grade than it is a steep one, with a tee mower.

The topsoil of the tees should be prepared as for putting greens, and drainage, wash and seepage should likewise be taken care of.

Tees are usually seeded to the same mixture as the fairway, only more care is taken to secure a thicker and tougher turf. Since tees are put to such hard usage, it is usually advisable to seed the tees before either the fairways or putting greens in order to give the grass longer to fill in. However, everything can not be done at once, and frequently the tees are let go, so that it is advisable to sod at least one set, on which the members may commence play, while the others may be seeded and be given more time for the turf to become established. On short holes the wear on tees is particularly severe, since iron shots are played from the turf and large divots result.

Special Problems of Sand Traps

On low areas sand traps are liable to become flooded and sometimes to remain so for days after a heavy rain, whether the soil is sand, clay, or silt. This flooding occurs also on traps built in heavy, close-textured soil, even though the traps may have plenty of elevation. Sand traps, whether around greens or in the fairways, should be more or less open in the front and elevated as much as possible in the rear. This form of architecture aids in the drainage of the traps as well as in giving the player a chance to see not only the location of the traps but to a large degree the extent of the hazard.

When traps are built on a soil which is comparatively impervious, the sand tends to wash to lower areas during heavy rains. Therefore the elevation of the rear of the traps must be more in effect than in reality. If the soil under the sand in the trap will readily absorb water, the danger of washing is lessened.

Except in traps built on these open or porous soils with sufficient elevation, the floor of the trap should have a grade not in excess of 2 feet in 50 feet. However, the effect of greater elevation and consequently greater visibility of the trap may be gained by constructing a long slope with a drop as small as 1 foot in 5 if possible, into the trap at the front. A total drop of at least 6 inches into the front of the trap is usually necessary to keep the sand confined in the area intended. If possible, the backs of the traps, or the sides away from the play, should be plainly visible. A steeper grade on these sides will help to make them noticeable, but often this effect will have to be gained by constructing slight mounds on these sides. The back of the trap and side away from the fairway or green should be graded not steeper than 1 foot in 2 feet, and less if possible. It must, of course, be borne in mind that there should be no area in the trap in which a ball might settle and from which it would be impossible to make a proper back-swing with the club. The sand should be splashed up against the back end and off-side grades of the trap so as to show up the trap at a distance. The mounds used in trap work should be planned to conform to the natural topography. Even though the grade into certain sides of the trap may be comparatively steep, the mound work may be made to conform to the landscape by dragging the backs of the mounds well away from the trap. Grades may vary due to the architecture of the trap; but for the sake of economy in maintenance, as well as for the appearance, the slopes from the backs of the mounds should be long enough to be cut with mechanical equipment.

A tile line should be placed in traps with poor drainage so as to carry off surplus water quickly. It is not necessary to run the tile line into the trap for more than one-third the length of the trap, since in such a comparatively small area the water will readily seep to the lowest point. Tile under sand is liable to shift and become choked or broken, and it should therefore be well protected. When tile is placed at depths of more than one foot beneath the sand, a fill of coarse stone topped with finer stone, gravel, or cinders and finished up to the grade of the bottom of the trap with 2 to 4 inches of inverted tough sod, will be found to be good construction. When there is not sufficient elevation to lay the tile one foot or more deep, greater care will be needed in the construction. In such cases the tile should be set firmly in the trench by packing field stones or similar material around the tile. The trench should then be filled with small stones or gravel to occupy cavities between the larger stones. The fill of these small stones or gravel should leave room for at least 3 inches of hard coal ashes or fine cinders. This fine layer should extend to within 1 or 2 inches below the top of the trench, while the remaining space will be taken care of with the sand in the trap.

In all cases when laying tile in sandy soil it is well to place a strip of heavy tar paper around the top half of each tile joint. This will help to keep the tiles from filling with sand before the packing has settled and the natural water channels are established. The drop in tile lines in traps should be not less than 1 inch in 5 feet.

AS WE FIND THEM

Found one green committee figuring on how to keep turf on tees slightly over 100 square feet in area. Greens were all close to 10,000 square feet. Couldn't cut down size of greens, for members would kick. All wanted sod on tees but could not afford to build them larger.

It must be admitted some members take as many as five or six strokes on each putting green, but even the best of them take at least one stroke on every tee. Why are courses built with such uneven distribution of expense on greens and tees?

Saw a line of tile being laid from a low pocket. Men were told to lay it 18 inches deep, and when they came to the ridge which cut off the surface water they still kept placing the tile exactly 18 inches below the surface.

Water will not run up over a hill through a drain tile any more easily than it runs uphill any other way. Later some green committee member will explain, "The trouble can't be poor drainage, for we already have a tile line through here."

On a construction job a battery of heavy tractors were watched slipping around across wet clay soil where some day a green approach would be located. After the soil became more thoroughly puddled and baked than are most country roads, there would probably be a thin layer of topsoil spread on to level off the rough spots before planting. In a few months players will begin to ask, "What is the trouble with the turf on those approaches?"

Discovered a new theory for aerating greens. A tile system is to be laid under the green and from this a long pipe is to be run up a nearby hillside and thence up a tree to give a chimney effect and create a draught under the green.

Some one has suggested that this pipe instead of running up the tree be connected to the 19th hole. Then when members start "blowing" about some of their shots they can be requested to direct their air currents down that pipe to help the great cause of aerating that suffering green.

A few years after the course was built it was decided to extend the water system to water some special landing areas and approaches. Decided to tap into the old water mains. By the time those mains were discovered the course looked like a badly shelled battlefield.

Some day, in addition to men and machines, there may be a little "foresight" used in constructing golf courses. If such a day ever comes there will be diagrams of water and tile systems placed on record. Then it will be easily possible to reach either without digging up the whole course.

They were clearing land for a golf course. "Oh, no, we haven't decided on the layout as yet. We first want to get things going and clear the place up a bit while we are making up our minds as to the arrangement of the course."

Some people are always "making haste slowly." How many magnificent trees and beautiful natural settings for holes are sacrificed to satisfy the demands of that early impatience of club members to "get things moving and cleaned up."

Some of the most beautiful golf holes are made attractive largely by their setting of trees. Architects may design and builders may construct beautiful holes—"but only God can make a tree."