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.