Building Golf Holes for Good Turf Management

By the Green Section Staff

of the United States Golf Association

edited by

Marvin H. Ferguson

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The USGA Green Section is concerned with maintenance of golf courses. It does not engage in golf course architecture.

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The Problem

Since World War II, we have witnessed phenomenal growth in new golf courses across the land. They have arrived in all sizes, shapes and descriptions. Unfortunately, most of them (including those with good design) have also arrived by way of poor construction methods.

It may take only a year to build a new golf course. But if the work is not properly done, it may take the next eight to ten years to untangle the mistakes and put the course in manageable order. Often initial errors can never be corrected.

Why is it that the here and now of construction invariably captures the attention of golf course developers, while the most important economic consideration of all—the untold years of maintenance that lie ahead —is hardly given a second thought?

The problem of poorly built golf courses usually stems from one of three sources:

1) A number of golf course architects knowledgeable in the field of design have, for one reason or another, generally failed to show a real understanding of fundamental turfgrass requirements. Not once or twice have they failed, but a general pattern of failure is the rule, not the exception.

2) Some totally unqualified individuals have entered the field of golf course architecture. They are superb in salesmanship but basically lacking in an appreciation of design, golfing values, course construction and maintenance.

3) Key men behind the development of new courses, i.e. those with an investment to protect, frequently hold the fallacious belief that, to do anything well, exorbitant costs are required and can never be recovered. They choose to compromise with the future.

Let's take a look at the problem sources.

Golf course design and construction is not easy work, especially if it is to be done correctly. But a close look at golf courses built during the past 20 years only strengthens the contention that experienced architects have been more concerned with layout and design than with the basic and essential agronomic requirements of their work. The point is easily illustrated.

Not many years ago, two rather renowned and contemporary golf course architects in the United States collaborated on a published article discussing the relationship between golf course design and turfgrass management. They wrote in part, "High quality turf is essential for good play, but it receives only casual player recognition if design is faulty and uninteresting." Good turf, they are telling us, will not compensate for poor design. (Of course the exact opposite is also true!)

The architects' statement may have validity if applied strictly to championship courses throughout the country. But the architect authors have overlooked the fact that the majority of golf courses in the United States today are not championship courses. Not every club member nor every golfer would want them that way. On the non-championship type courses, of which there are so many, good turf has, is and will continue to compensate for questionable design. For proof, look only at the renovation and rebuilding work now going on. In nearly every case, it is being undertaken to correct agronomic deficiencies of earlier architecture, not design deficiencies. The man paying most of today's golf bill, the average golfer, has time and again demonstrated his keen interest in a green, well-groomed and well-turfed golf course. It is totally unfair to contend that he only "casually recognizes" golfing turf.

This should not be construed to mean that design is unimportant or architects unnecessary. Indeed and beyond question, they are essential in the development of any golf course. Furthermore, they should be given complete freedom in design when they undertake the project. But the archi-

tect is not omnipotent. He is not all-knowing, particularly in agronomic matters. For the good of golf, he must devote greater attention and effort to this phase of his work.

The professions of golf course architecture and construction have had an additional problem in recent years. At a time when golf courses are being built so rapidly, it is inevitable that incompetent and basically unqualified individuals will become active in their field. After all, one is not necessarily a "golf architect" just because he is a scratch golfer, a retired professional, a superintendent or a landscape designer. There are untold examples where so-called "architects" through haste, lack of knowledge, lack of supervision, indifference, and in some cases through greed, have left a new club with insurmountable problems.—problems that must be solved another day. Anyone involved in developing a new course should be aware of and alert to this dangerous situation. Two examples will amplify the point.

In a major newspaper in the southwest, a feature story was devoted to a "young and promising golf course architect." During the interview the young man was asked, "How much formal education does it take to become a golf course architect?" He replied, "None, if you know enough bulldozer operators. It just takes practical knowledge."

Now follow a scene shift to one of the great golf courses in America—Merion, built in 1910. In Joseph C. Dey's story on "Merion" (August, 1966 USGA Golf Journal), he tells of the "amateur architects" of Merion of that day. They were a group of businessmen and golfers interested in developing a new golf course. They spent two energetic years in planning and construction. One of their members spent over two months in England and Scotland studying and sketching renowned golf courses there. This group may have started out as "amateurs," but they spent over two years putting together the elements of strategy, construction and design in building this outstanding course. And then, they were fortunate enough to have the assistance of Mr. Joe Valentine, one of the earliest and finest golf course superintendents in the country.

Merion proves that amateurs can do the job. But it takes certain qualities not in the possession of everyone. Qualities such as inherent talent for design, adequate time and financing, and understanding of golf, dedication and self sacrifice. It takes much more than merely knowing several bulldozer operators!

Finally, there is the question of costs. At one time or another, every experienced architect has had a client with 130 acres who wants a championship 18 hole course measuring 7,000 yards. The client also wants 100 homesites developed on the property, a clubhouse with adequate parking, a driving range, roads, a ten-acre lake and some service buildings as well. And he wants the course built for $200,000, including the automatic irrigation system!

Of course, it can't be done. It's unreasonable of any client to expect an architect to build a cheap palace. Similarly, it's unreasonable of any architect to overdesign and overcharge for good construction. In any undertaking, certain basic costs must prevail, and compromising these costs for expediency or for profit is not the answer.

If it is too costly to build a green correctly, it will prove far more costly to build it incorrectly. In the long run, the cheapest way of doing any job is to do it right the first time.

For help "in doing it right the first time," we would hope this publication of Green Section of the United States Golf Association will prove of value. We are not omnipotent either. But when it comes to agronomic matters and construction considerations, we believe we have something significant to say. We have seen the pitfalls, the abuses, the shortcuts and the excesses of the past.

Anyone contemplating the construction of a new course should find valuable informa-

tion in the following pages. Progressive architects recognize that sciences and arts other than pure design are involved in planning the golf course. It is when good design principles are blended with golf strategy and accepted agronomic techniques that a product to be proud of is produced.

Golf is played on grass. Grass responds to good management. Good management begins with good construction. It is in this context that this small voice is raised. It is to this cause that this publication is dedicated.

General Considerations

A wise man once said, "The longest journey starts with the first step." So it is in the development of a new golf course; General Considerations are the first step. It is during this initial phase of development that the tone is set for the entire project. Will it be done in a meticulous way with care and attention given to every detail; or will it become a slam-bang project with completion dates and economies the only measure of progress?

If your thoughts and studies have brought you to the point of seriously planning a new golf course, you would do well to take a searching look into the subjects of Site Selection; Arrangement of Course Features; The Traffic Flow Problem; and Time Required for Construction.

Site Selection

Today's golf course developer rarely has the opportunity actually to select a specific site for his golf course. Indeed, he is fortunate if a piece of property becomes available in even a general area he may have selected, such as the north or south side of a city. Property selection, in the true sense of the term, is almost of another era. Land availability and land costs in an area capable of supporting a golf facility are the prime consideration. In real estate development projects, the golf courses are usually placed on the most marginal or poorest piece of land. If you are fortunate enough to have two or more pieces of property available for the course, your golf course architect should be consulted and should assist you in the final selection.

Acreage Requirements

Acreage requirements will vary according to topography, length of course desired, the presence of trees, ponds, lakes, streams, etc., and the desire of the builders for adequate separation of holes. Because land prices always seem high, the usual result is that an insufficient amount is purchased for the course.

If we are to consider a flat piece of land, a minimum of 120 acres will be needed for an average 18-hole course. It would probably measure close to 6,300 yards in length and the holes would be approximately 65 yards wide. Bear in mind that this is a minimum figure for flat ground. If you wish to develop a course with character, good separation between fairways, a driving range, or if the land is rolling and contains ponds, lakes or streams, from 150 to 200 acres will be needed for an 18-hole layout. This will give your architect an ample opportunity to develop an exceptionally fine golf facility.

Since golf courses invariably raise the value of land surrounding them, it is wise to purchase or at least develop an option on as much land in the area as possible. Any golf club able to purchase a tract of 200 to 300 acres would indeed have a bright future.

Terrain Features

If one looked for an ideal setting for a golf course, he would probably select a property with gently rolling hills, high plateaus, pleasing valleys with meandering streams and lakes, natural sand dunes and virgin forests. Spectacular scenery such as an ocean or mountain ranges would add further interest to the setting. Such sites are few and far between. Population centers and economics dictate where most golf courses are to be built and

rarely does the above combination of terrain features exist.

Today's golf courses exhibit a wide variety of terrain ranging from flat land (as long as it can be adequately drained) to rolling and even hilly terrain. The advent of the electric cart now makes it possible for good architects to develop interesting layouts even in moderately hilly terrain.

Steep hills which would require a considerable climb for one or more holes should still be avoided, however. A heavy climb has been defined as one requiring an elevation increase of 100 feet or more over 400 to 500 yards. In other words, land with a number of hills closely spaced should generally be considered unsatisfactory, whereas land with long, gradual undulations can be brought into play and proved to be very satisfactory.

When considering hilly terrain, pay particular attenion to the valleys or canyons involved. If they are too narrow, they will not prove satisfactory for fairway purposes. A minimum suggested width for one hole in canyon or valley country is 60 yards. If two parallel holes are to occupy the valley floor, it should be at least 150 yards wide. Furthermore, bear in mind that the narrow valleys between hills also act as natural drainage ways and a future problem might develop because of washing and erosion from runoff.

Land that is moderately to heavily timbered offers a particular charm for golf course development. Nevertheless, bear in mind it is expensive to clear land of this type although the final results will produce an outstanding setting. Trees should be cleared sufficiently around tees and greens so that adequate sunlight will reach these important and heavily used areas.

When clearing heavily timbered land, both timber and stumps should be thoroughly removed. In order to "save money", a number of clubs have made the mistake of burying the logs and covering over stumps. It does not take many years before this poor technique begins to show. Uneven contours, pot holes and impossible playing conditions develop that must be corrected later at a considerable expense.

A final word concerning terrain features. Almost every site has some degree of natural beauty and charm. The experienced golf architect will take advantage of these features and mold the golf course into them. In the hands of an inexperienced architect or construction contractor unfamiliar with golf course building, natural beauty of an area can soon be destroyed. With modern grading equipment, it doesn't take long to level an area or push over valuable trees that could become an important asset to the course. Guard against highway or parking lot type grading on your golf course.

Take advantage of the natural beauty and natural settings and fit the course into them. This is the sign of excellence in architecture. The golf course, on completion, should appear as if it was formed by the winds, the glaciers, the rivers and streams of centuries ago. Obvious artificiality should be totally avoided.

Soil Types

If site selection is a rare happenstance in today's golf course development, the selection of a piece of property with a desirable soil type is even rarer. The architect and construction contractor must generally "make do" with whatever type of soil they find on the property (except for greens, collars and tees). With today's modern maintenance equipment and turf management skills, good fairway and rough turf can be produced on sites with a wide variation of soil types, from practically pure sands to the heavy clays or adobe type soils. However, the poorer the soil type, the greater the care must be during construction, the better the overall drainage must be, and the more exact the management program in later years.

A course fortunate enough to have sandy loam on the property will surely have fewer maintenance problems in the years ahead.

This type of soil drains nicely while retaining sufficient moisture for good grass growth. It can be easily worked and contoured during the construction phase. Should heavy rains or snow occur, it will dry out fairly rapidly. Furthermore, a sandy loam type soil will provide more nearly uniform playing conditions throughout the year. There will be fewer wet spots and fewer dry spots throughout the course.

Pure sand or very sandy soils have the advantage of resisting compaction and the ability to support good turfgrass production. Furthermore, turfgrasses will tend to build their own organic matter in this type of soil over a period of years and improve its moisture-holding capacity. A site with sandy soils also lends itself to natural hazards throughout. Very sandy soils have the drawback, however, of requiring close irrigation management during the summer months and usually require higher fertility levels throughout the year.

Very heavy clay soils and those high in silt content are the least desirable of all for golf course use. They compact readily, do not drain very well and uniformity of playing conditions is difficult to achieve regardless of the season. They always seem to be too wet or too dry. Extreme attention must be given to the final grading of these soils to insure good surface drainage. Clay soils are also difficult to work during the construction phase. Should heavy rains or snow occur, many weeks may be needed before construction can be continued.

Gravelly soils are frequently encountered and, surprisingly enough, usually provide good golfing conditions after an adequate sod has been established. Although they drain well, they will require some additional work prior to seeding. Mechanical equipment should be used to remove the larger stones. The additional expenditure will prove more than worthwhile in the years ahead. If the graveled area is confined to one section of the property, a better quality soil might be brought in from some non-use area and spread over the gravel. In any case, the establishment of a good sod at the earliest possible moment is essential. This would require adequate seeding rates, good fertility levels and proper irrigation practices.

In many cases, a particular piece of property will have a number of different soil types on it. If this is the situation, one of the first projects should be to stockpile the best soil available. This can be used as a source of topsoil in covering approach and collar areas of greens and tees. If suitable, it should also be used as the soil component in the sand, soil and organic matter mixture in constructing greens.

For some reason there is a widespread belief that riverbed soil is ideal as a source of topsoil for use on a golf course. In most instances, nothing could be further from the truth. So-called river soils are usually high in silt content and for this reason should be avoided at all costs. Silt is not a desirable component in golf course soils and is particularly bad for putting green, tee or collar use. It compacts readily and it destroys good water infiltration rates. Therefore, avoid using riverbed soils or any others that may have a high silt content unless they have definitely been shown to have less than eight to ten percent silt and fine sand particles.

Drainage

During the early 1920s United States Department of Agriculture agronomists were occasionally asked to list the essential requirements for growing grass on a new golf course. One of the classic replies of that day was:

> "Really, there are only two points you should keep in mind for this situation. (1) Use as much common sense as possible during construction and (2) provide good drainage. Now, if you find there's not much common sense on the job, you had better provide for that much more good drainage."

And so it is today. Good drainage is abso-

lutely essential on golf course property, and it is during the planning and construction phase that good overall drainage on the property must be developed.

Basically, there are two types of drainage: surface drainage and subsurface drainage. Surface drainage is the fastest and best way of removing excessive water from a piece of property. With today's engineering know-how and grading equipment, interesting swales can easily be developed throughout the property during construction and these will handle excessive rainfall and runoff. Low, flat areas should receive particular attention. If they are extremely low and flat, lakes and pumps may have to be used to solve the drainage problem. Where impervious subsoils are present, surface drainage takes on even greater significance.

Throughout construction, close attention should be given to the seemingly unavoidable development of pockets or small catch basins throughout the golf course. These areas are frequently found on fairways, tees, approach areas and greens as well. Pocketed areas can easily be corrected with light gradings during the final phase of construction. However, once the grass has been sown, they become extremely difficult to correct. They can cause a major maintenance problem and considerable displeasure for the golfer.

If for some reason pocketed areas cannot be corrected by surface drainage, catch basins or dry wells are sometimes used. Catch basins will remove surface water rapidly and a tile line will carry the water into the regular underground drainage system on the property. Dry wells or French wells are frequently used when an impervious soil layer prevents rapid movement of water into the lower soil profile. They are particularly effective when they can be dug deep enough to reach sandy or pervious material at a deeper level.

This brings us to a discussion of subsurface drainage. Although subsurface drainage is usually accomplished by tile line installation, sometimes gravel or crushed rock is used to fill the ditches and to facilitate water movement through an area. In later sections of this publication, various types of tile line systems will be explained. However, let us say here that drainage lines must be designed to meet the particular condition under consideration. For example, if seepage is occurring on a particular area of the golf course that will come under play, the best solution lies in installation of an intercepting tile line. This line must be installed up-slope and deep enough to catch the water seeping from higher elevations before it comes to the surface at a lower level.

There are various types of tiles now on the market. They include the unglazed agricultural tile, cement tiles, plastic, and asphalt composition type tile materials. The latter two usually come in six- and eight-foot lengths. They are easier to install for this reason.

When investigating a piece of property for golf course development, be alert to the overall drainage characteristics of the land. Swampy, boggy areas are usually distinguished by the presence of rushes, sedges and similar type plant life. Soils that are persistently wet and soggy will usually have a blue or mottled color in the subsoil and this is a sure indication of poor drainage. Corrective measures will be needed if these areas are to come into play. Waterlogged soils are unsatisfactory to the golfer and impossible for the turf manager.

If a drainage problem exists, something must be done to correct it. Good drainage is just as important in limited rainfall areas as it is in regions with adequate rainfall. In fact, regardless of course location, tile lines are essential in putting green and tee construction. The tiles will more than compensate for their slight additional cost.

Frequently, no thought at all is given to adequate drainage of bunkers (sand traps). If the subsoil is impervious, tile line installation for the bunkers is essential. In many cases, modern-day architects will tie tile lines from bunkers around putting greens

into the putting green tile drainage system. In addition, keep in mind the importance of preventing surface water from running into bunkers. This can best be done by raising the ground next to the trap and diverting the surface flow in some other direction.

Former Land Use—Vegetative Cover

If the site has supported any type of agricultural growth in the past, it will surely support good turfgrass production. Even poor soils will respond to good management. For example, on an exceptionally sandy or gravelly soil, good natural drainage exists but an adequate fertilization program will be necessary in order to guarantee good turf. In fact, the best crop for improving any type of soil is grass. But it does require proper management.

If the vegetative cover on a selected site indicates poor drainage and boggy, swampy conditions, your first consideration must be given to improved drainage. If this is done, and the selection of the proper grass for such an area is coupled with good soil preparation and fertilization practices, a very acceptable turfgrass cover can be established.

In the southwestern and western regions of the country, the proposed site should be closely scrutinized for evidence indicating the presence of an alkali problem or the accumulation of soluble salts. If this condition exists, the land will require a great deal of modification and alteration. Drainage characteristics must first be improved. In fact, adequate surface and subsurface drainage is the only answer to this type of land reclamation for golf course utilization. Once the drainage has been provided, considerable leaching must take place to remove the high salt concentration. In all likelihood, the importation of better soils for use in contouring greens and development of tees will be necessary.

Many people consider old farmland ideal for golf course construction and utilization. In most instances, the soil is good but drainage problems are frequently encountered and pocketed areas need correction. Furthermore, if the soil has been plowed for a number of years, a plow sole of compacted soil may be present in the lower soil profile and will later appear throughout the fairways if not broken up. In this case, subsoiling is necessary before attempting to final-grade the fairways and roughs.

Availability of Water

Water availability, if not of greater importance, is at least of equal importance to soil types, drainage and terrain features. Without an adequate water source, good golfing turf cannot be produced.

Prior to the 1960s, an 18-hole golf course with a well that produced 500 gallons per minute or more considered itself to have a very adequate supply of water. However, since the 1960s, most turfgrass specialists consider the minimum needs for an 18-hole course now at 1,000 gallons or more per minute. Water requirements for golf courses have increased that much in recent years. The increase is due primarily to a desire for better turf and more nearly uniform playing conditions throughout the course. In addition to adequate irrigation for tees and greens, members now expect fairways and rough areas to have a uniform turfgrass cover and green color throughout the golfing season. Even in areas with an above average annual rainfall, an irrigation system capable of total coverage is highly desirable.

When determining water requirements for a golf course, the maximum use rate of the grass must be considered. As a rule of thumb, most areas with a moderate summer climate (i.e., day temperatures between 60 to 80°) will require one and one-quarter inches of water per week during the maximum use season. Where day temperatures range from 75 to 100°, the maximum use rate of one and three-quarter inches per week is suggested. Areas with temperatures over 100° every day will require two and one-half inches of water or more per week.

Of course, these are average figures and will vary according to the species of grass, mowing practices, soil types, climatic factors, fertility levels, etc. They are intended only as a guide in determining water needs.

As water requirements increase in all areas of our economy, the quality of water becomes a serious factor. In some areas, water for agricultural purposes will probably decline somewhat in quality during the coming years. According to the U.S. Department of Agriculture, irrigation water carrying 1,200 parts per million of soluble salts is considered fairly acceptable for most crops. Water containing 2,000 parts per million is considered to be very high in soluble salts. In southern California, Colorado River water is widely used and contains about 700 parts per million. Even at this rate, some golf courses have experienced a serious salt accumulation problem where Colorado River water was used exclusively. Of course, poor drainage characteristics and the evapo-transpiration rate also becomes involved. There is no doubt that water quality is going to become a bigger and more important factor in future irrigation of agricultural lands in this country.

Availability of Power

When considering a possible site for your new golf course, don't overlook the availability of electric power for golf course maintenance purposes. In addition to the electrical requirements needed in the shop maintenance area, automatic irrigation systems and pumps will also require a dependable source of electricity. A check with the local power company concerning the availability of electricity on the particular property in question should be made before final papers are arranged.

Arrangement of Course Features

When developing a piece of property for golf use, it is well to look at the entire project as a whole. For example, selecting the site for the clubhouse should not be an arbitrary decision. Rather, the clubhouse location should fit into the overall plan and your golf course architect should be consulted concerning its location. A poor choice of clubhouse site can lead to serious problems for the course architect and destroy much of the potential the land may hold for golf course utilization.

Location of the maintenance equipment area must also receive serious consideration. It should be accessible to all parts of the course and, in most instances, attempts are made to locate it as closely as possible to the center of course activities. Some golf course properties are long, narrow and spread over considerable terrain. In situations of this type, sub-stations are developed for maintenance equipment and considerable time is thereby saved in transportation requirements; in fact, maintenance men will not report to the main maintenance area each morning or night but go directly to their section for the day's work.

Adequate planning must be given to the proper location of a service road to the maintenance equipment area. At the same time, consideration should be given to the proper location of utility poles for electricity and telephone service. Rights of way for these services must be determined but they should not interfere with play.

Other roads will be needed throughout the golf course for transportation of maintenance equipment. In some instances, golf cart paths are developed in conjunction with these maintenance roads. The roads should never cross fairways or pass near tees or greens if at all possible. They should be well planned in advance and located as unobtrusively as possible.

All parts of the golf course must be accessible to maintenance equipment. For example, if one or more fairways are located on a high plateau or hillside, some provision must be made to allow a tractor and mowing units to reach that particular area. Similarly, if bridges are needed for crossing streams or ponds, they must be wide enough to accommodate large equipment and strong enough to support the heaviest equipment.

Surprisingly, a number of golf courses have been built with narrow, weak bridges with no thought at all given to the requirements of maintenance equipment.

Traffic Flow

It is during the design and construction phase that future problems in handling the flow of golfer traffic around the course can be minimized. Heavy, concentrated traffic is one of the most serious problems on today's golf courses. The turf soon wears thin, mud holes develop and an unpleasant situation (that is hard to correct at a later date) rapidly develops.

Today's experienced golf course architect will constantly have the golf cart traffic problem in mind as he lays out a new course. By properly locating tees, the proper placement and arrangement of sand bunkers, the use of mounds and elevations, tree plantings, vistas, etc., the golf architect can contribute much to future maintenance by giving alternate routes to the golfer on foot as well as in a cart. This is a study worth every minute devoted to it.

Time Required for Construction

To the novice, constructing a golf course may seem to be an easily and quickly accomplished task. In actual fact, every detail of the operation should be closely supervised and continually checked.

A number of factors enter into the time requirement. For example, weather conditions may be adverse for many months of the year. Delivery of supplies or equipment may be delayed for one reason or another. Contractors may be unable to arrive on your site on the promised day. Delays may be encountered from labor disputes, county or state permits and inspections, utility company delays, etc. Even well-planned and coordinated operations will usually encounter some delays.

Under these conditions, there is always the tendency to overlook little details in order to hurry the job along. We would urge and caution you not to follow this tempting alternative. For it is during the construction phase that every project and every detail must be done correctly. If you decide to compromise and take corrective action at a later date, it is going to be far more costly and the golf course will have suffered months if not years before the corrective action can be taken.

If everything runs smoothly, if there are no major delays, and if adequate equipment and manpower are available for construction, it may be possible to open the course 12 months after construction begins. However, this assumes greens will be planted and given at least six months to develop and mature before putting them under play. Fairways, collars, approach areas and tees must have at least four months of good growing weather before opening day. Even this schedule is forcing the issue. It would be far better to give your grass at least a full year to mature and develop.

The temptation is great to open a new course too soon. The grasses appear to be ready for play within a few months, or golfers can hardly restrain themselves until opening day. This is the time for a firm attitude. If the course is opened too soon, considerable seen and unseen damage will occur and many months if not years will be needed to correct this unfortunate mistake. On the other hand, if the turf is given at least five to six months of good growing weather without subjecting it to play, it will establish itself and develop a tight, resilient and wear-resistant sod.

In the final analysis, there are really three important factors involved in developing a new golf course:

1. Know-how in maintenance, construction and design.
2. Adequate financing in order to do the job right.
3. Adequate time to enable turfgrass establishment.

Overlook any one of these factors and your new golf course will not live up to its potential. If you have taken care of the first two requirements, you would certainly not want to overlook the third.

Putting Greens

In a model round of golf, where the player performs that which is expected of him on every shot, he will play 36 of his 72 strokes **on** the putting green and he will play 18 more **to** the putting green. Thus the putting green figures in three-quarters of the golf strokes in a model round. It is little wonder that golfers demand excellent turf on this relatively small but tremendously important area.

Because the putting green is so important to the game, the club concerned with building a golf course and the architect who serves the club can justify very great effort toward the end of making the putting surface as nearly perfect as possible. Many factors are involved, and all should be considered.

Location

A person familiar with golf course maintenance can visit a golf course under construction and predict with amazing accuracy which greens on the new course will be easily kept and which will cause difficulty.

How can he do so? Because he knows the necessity for good air circulation over the surface of the green, the importance of surface drainage, the detrimental effects of shade and the fact that the concentration of traffic caused by design features will take a toll.

Location of the green is as important to its maintenance as it is to the integrity of the golf hole. When the location is unsuitable on either count, the architect has failed.

Air circulation is one of the prime requirements of good putting turf. Close mowing of greens and the compaction imposed by traffic are invariably coupled with relatively shallow roots. Shallow roots imply frequent applications of water; this in turn is associated with high humidity unless air movement can disperse the moisture vapor. High humidity, a favorable temperature, the presence of a disease-causing pathogen, and a susceptible host add up to diseased turf.

Thus, one of the cardinal rules of green location is never to place it where a barrier will intercept the prevailing breeze during hot months. The rule has been violated countless times because a particular location has strategic value or because a natural setting provides a particularly attractive location. Strategic values and beauty are important, but if the putting surface is poor, these attributes quickly lose their charm.

Drainage is always a consideration. Surface water draining from higher ground should not flow over the green. Seeps arising from slopes should be intercepted successfully upslope from the green, or else the green should be relocated. Finally, the green and the bunkers and mounds surrounding it should be so located and shaped that surface water resulting from heavy rains will move quickly away.

Shade is a detriment to good turf. Trees in the vicinity of the green are tolerable and in some cases desirable, but they should not shade the green for more than a few hours each day. Neither should trees be so near that their roots become troublesome in the green.

Another matter affecting the location of a green is its relationship to the tee of the next hole. Players can be guided without being aware of being guided if the green is so shaped and oriented in relation to the following tee that the placement of the flagstick and the tee markers for the next hole enables the use of alternating traffic patterns. Conversely, the thoughtless arrangement of flagstick placement areas, tee orientation, and bunkering can prescribe paths where no relief from traffic is possible.

Design Features

Slopes and contours are a major concern in putting green maintenance. Slopes surrounding the putting green should be gentle

enough to permit mowing with gang units, but steep enough to support good surface drainage. On the putting surface slopes should generally be arranged to carry surface water off the green in more than one direction. In any case, slopes should not dump all surface water off the front of the green in the approach area.

Contours on the putting surface can add much to the character of the green and may affect the difficulty of play very greatly. They are desirable so long as they are gentle. When they become severe, then maintenance suffers. The area available for flagstick placement is diminished by sharp contours, and relatively large greens are required for adequate traffic distribution. If greens are both small and heavily contoured, then flagstick areas necessarily become worn and compacted.

Size

It is almost axiomatic—according to books and articles on golf architecture—that the size of the green must be related to the length of the approach shot. There is one difficulty associated with this philosophy. Frequently on the short par-3 holes, golf shots are played with a high trajectory and ball pitting becomes quite serious. If the size of the green restricts the availability of flagstick placement area, such a surface may suffer badly. It would appear that imaginative bunkering and contouring will permit the use of a small target area on a relatively large green. Thus flexibility in the play of the hole and satisfactory flagstick space may both be provided while retaining the difficulty associated with the small target.

The absolute size of putting surfaces is a matter of debate among partisans of various architectural styles. The range is from about 4,000 square feet in the actual putting surface to about 12,000 square feet. There are a few extremes, of course, on either side of this range. From the maintenance viewpoint, a size of about 6,500 to 7,500 square feet is preferable. A green of this size, if not severely contoured, will provide adequate room for frequent flagstick movement. Smaller greens suffer from traffic concentration, while larger ones simply increase the area to be maintained intensively.

Construction

Golf course design and golf course construction have been considered arts rather than sciences. The individuality and the character of golf courses in this country have resulted from the artistic talents of some of the great architects in whose minds they were conceived. Likewise, construction methods have been developed as a result of individual experiences and individual preferences. It is a tribute to those whose efforts have gone into golf course building as well as to those who maintain them that so many courses have stood up well over the years.

The pace of golf activity and the traffic on golf courses since World War II, however, have never been equaled in our country. Many construction methods that were satisfactory in an earlier day will no longer produce greens which will withstand the wear that is now imposed upon them.

Because of these considerations, the USGA Green Section has since 1948 interested itself in construction methods and in a study of the physical problems of soils used in putting greens. Research in these matters has been sponsored by the Green Section at Beltsville, Md., Oklahoma State University, University of California, Los Angeles, and since 1954 an intensive program of study has been supported at Texas A&M University.

It has been found that the problems of construction procedures and methods and those of physical behavior of soils cannot be separated. The two matters are related and must be considered together if a desired result is to be produced. The procedures outlined here may well be used as the basis for specifications which a club may present to the prospective golf course builder.

Such specifications will place no limitations upon the individuality nor the artistry of any architect. They will, however, provide a guide for the builder and for the club which wants to be assured that the greens they build will continue to provide good playing conditions for many years.

The basic considerations underlying the specifications and methods presented are those of good drainage and resistance to compaction. These ends cannot be achieved without some compromise. A highly permeable soil which drains readily offers some problems in the establishment of turf. It is loose and sometimes may create difficulty in the changing of cups. These are minor problems, however, when weighed against the advantages of rapid drainage, good aeration, deep rooting, protection against diseases, protection against overwatering, protection against salt problems, a putting surface which holds a shot without being overly wet and one which resists pitting by golf balls.

The methods and specifications outlined in the following pages represent the best thoughts of the USGA Green Section Staff and of numerous soil scientists who have given serious attention to the problem. It is hoped that they will result in more satisfactory and less troublesome putting greens throughout the nation.

1. Subgrade

The contours of the subgrade should conform to those of the proposed finished grade, with a tolerance of plus or minus 1". The subgrade should be constructed at an elevation 14 inches below the proposed finished grade. The subgrade should be compacted sufficiently to prevent future settling which might create water-holding depressions in the subgrade surface and corresponding depressions in the putting surface.

Where terrain permits, it is possible to build the subgrade into the existing grade or to cut it into the subsoil. It is not necessary to elevate or build up the green unless design considerations dictate the desirability of doing so.

It will be noted that courses of materials above the subgrade consist of 4 inches of gravel, 1½ to 2 inches of coarse sand, and 12 inches of topsoil. Thus the total depth will be 17½ to 18 inches. However, this fill material will settle appreciably, and experience indicates that 14 inches will be the approximate depth of these combined materials after settling.

2. Drainage

Tile lines of at least 4-inch diameter should be so spaced that water will not have to travel more than 10 feet to reach a tile drain. Any suitable pattern or tile line arrangement may be used, but the herringbone or the gridiron arrangement will fit most situations.

Cut ditches or trenches into the subgrade so tile slopes uniformly. Do not place tile deeper than is necessary to obtain the desired amount of slope. Tile lines have a minimum fall of .5%. Steeper grades can be used but there will seldom be a need for tile line grades steeper than 3% to 4% on a putting green.

Tile may be agricultural clay tile, concrete, plastic, or perforated asphalt-paper composition. Agricultural tile joints should be butted together with no more than ¼" of space between joints. The tops of tile should be covered with asphalt paper, fibreglass composition, or with plastic spacers and covers designed for this purpose. The covering prevents gravel from falling into the tile.

Tile should be laid on a firm bed of ½" to 1" of gravel to reduce possible wash of subgrade soil up into tile line by fast water flow. If the subgrade consists of undisturbed soil, so that washing is unlikely, it is permissible to lay tile directly on the bottom of the trench.

After the tile is laid, the trenches should be backfilled with gravel, care being taken not to displace the covering over the joints.

3. Gravel and Sand Base

a. The entire subgrade should be covered with a course of clean washed gravel or crushed stone placed to a minimum thickness of 4 inches.

The preferred material for this purpose is washed pea gravel of about ¼" diameter particle size. Larger gravel or stone may be used, but it is important that changes in size between this course of material and the succeeding one overlying it not be too great. Otherwise, smaller particles from overlying material will wash into the gravel, clog the pores or drainage ways and thereby reduce the effectiveness of the gravel.

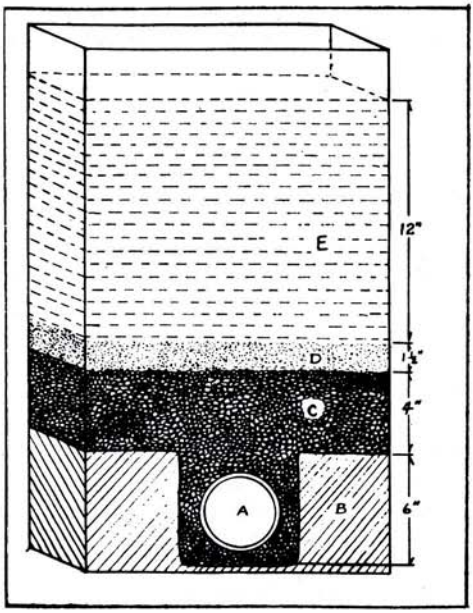
The maximum allowable discrepancy appears to be 5 to 7 diameters. In other words, if ¼" pea gravel (about 6 mm.) is used, then the particles of the overlying course should not be less than 1 mm. in diameter. If stone of 1-inch diameter were used, it would be necessary to include a course of pea gravel to prevent the movement of smaller soil aggregates into the stone.

b. When the gravel is in place, assuming that pea gravel has been used, a 1½" layer of coarse washed sand (commercial concrete sand is satisfactory) should be placed to a uniform thickness over the gravel.

The tolerance for error in the thickness of gravel and sand courses should be limited to plus or minus .5 inch.

A profile of a properly constructed putting green is illustrated in Figure 1.

Figure 1
CROSS-SECTION OF A PUTTING GREEN PROFILE SHOWING A TRENCH AND TILE LINE



A. 4-inch diameter tile.
B. Subgrade of native soil or fill material.
C. Gravel—preferably pea gravel of approximately ¼" diameter. Minimum thickness 4 inches.
D. Coarse sand—this sand should be of a size of 1 mm. or greater. One and one-half to 2 inches in thickness.
E. Topsoil mixture. Minimum thickness of 12 inches.

4. "Ringing" the Green

When the courses of gravel and sand are in place and outlets have been established for subsurface water (through tile lines), the green should be "ringed" with the soil which is to be used for aprons and collars. This soil should be placed around the green and any contours established in such a way that they will blend into the putting surface.

The next step is to fill the depression, which represents the putting surface, with the prepared topsoil mixture described in the following paragraphs.

5. Soil Mixture

A covering of topsoil mixture at least 12 inches in thickness should be placed over the sand and gravel layers.

The soil mixture should meet certain physical requirements.

Permeability—After compaction at a moisture content approximately field capacity as described by Ferguson, Howard and Bloodworth, a core of the soil mixture

should permit the passage of not less than ½ inch of water per hour nor more than 1½ inches per hour when subjected to a hydraulic head of .25 inches.

Porosity—**After compaction,** a sample of the soil mixture should have a minimum total pore space of 33%. Of this pore space, the large (non-capillary) pores should comprise from 12 to 18% and capillary pore space from 15 to 27%.

Information on bulk density, moisture retention capacity, mechanical analysis, and degree of aggregation in the hands of a soil physicist may be helpful in further evaluating the potential behavior of a putting green soil.

Few natural soils meet the requirements stated above. It will be necessary to use mixtures of sand, soil, and organic matter. Because of differences in behavior induced by such factors as sand particle size and gradation, the mineral derivation and degree of aggregation of the clay component, the degree of decomposition of the organic matter, and the silt content of the soil, it is impossible to make satisfactory recommendations for soil mixtures without appropriate laboratory analyses.

The success of the method of construction herein described is dependent upon the proper physical characteristics of the soil and the relationship of that soil to the drainage bed underlying the green. Therefore a physical analysis of soil should be made before the soil components are procured.

When the proper proportions of the soil components have been determined, it becomes extremely important that they be mixed in the proportions indicated. A small error in percentages in the case of a plastic clay soil can lead to serious consequences. To insure thorough mixing and the accurate measurement of the soil components, off-site mixing is advocated.

Any soil physics laboratory which is equipped with the facilities to carry out the measurement described by Ferguson et al can prescribe a soil mixture for putting green use. USGA Green Section offices can provide names of laboratories so equipped upon request.

6. Soil Covering, Placement, Smoothing and Firming

When soil has been thoroughly mixed off site, it should be transported to the green site and dumped at the edge of the green. Padding the edge of the green with boards may be necessary to prevent disturbance by wheeled vehicles of the soil previously placed around the outside of the putting surface. A small crawler-type tractor suitably equipped with a blade is useful for pushing the soil mixture out onto the prepared base. If the tractor is always operated with its weight on the soil mixture that has been hauled onto the site, the base will not be disturbed.

Grade stakes spaced at frequent intervals on the putting surface will be helpful in indicating the depth of the soil mixture. Finishing the grade will probably require the use of a level or transit.

When the soil has been spread uniformly over the surface of the putting green, it should be compacted or firmed uniformly. A roller usually is not satisfactory because it "bridges" the soft spots.

"Footing" or trampling the surface will tend to eliminate the soft spots. Raking the surface and repeating the footing operation will result in having the seed or stolon bed uniformly firm. It should be emphasized that the raking and footing should be repeated until uniform firmness is obtained.

Whenever possible after construction, saturation of the soil by extensive irrigation is suggested. Water is useful in settling and firming the surface. This practice will also reveal any water-holding depressions which might interfere with surface drainage.

7. Sterilization of Soil and Establishment of Turf

These steps may be accomplished by following well-known conventional procedures.

These seven steps in construction pro-

cedure tell **how** the work should be done. It may be well to reexamine each step with the aim of considering **why** it should be done in that way.

The Subgrade—When a new green is built and the subgrade is contoured, it frequently happens that there is a rather large amount of fill. It is very difficult to compact filled areas sufficiently to preclude further settling. However, the builder must strive to prevent further settling if at all possible. If uniform layers of gravel, sand, and soil overlay the subgrade, it is obvious that any settling of the subgrade will result in a corresponding settling of the top. Therefore, the thorough compaction of filled areas is necessary if the green is to maintain the contours built into it.

Tile Drainage—It is commonly believed that the use of a gravel layer provides adequate drainage and that the installation of tile is a needless expense. No doubt there is good reason for this belief in many cases. However, when large amounts of water are moving through soil under conditions of heavy rain or rapid irrigation, and where the water must move a considerable distance to reach an outlet, tile lines aid in the removal of excess water. It is also true that despite the best efforts to compact the subgrade, it sometimes settles after construction and "pockets" appear. Tile lines help to remove such trapped water. A putting green is expensive to build and the relatively small additional cost of adding tile drainage appears to be a small price for the insurance it provides.

Gravel and Sand Base—In a few cases builders have used tile and have then assumed that there is no need for a gravel base. This assumption is the result of a failure to understand how water moves in the soil. Lateral movement of water is relatively small unless there is a barrier which impedes its downward movement. See Figure 2. Therefore when tile is placed near the surface it must be very closely spaced if it is to remove much of the excess water. Conversely, if it is spaced at intervals of more than 4 or 5 feet, it must be placed very deeply.

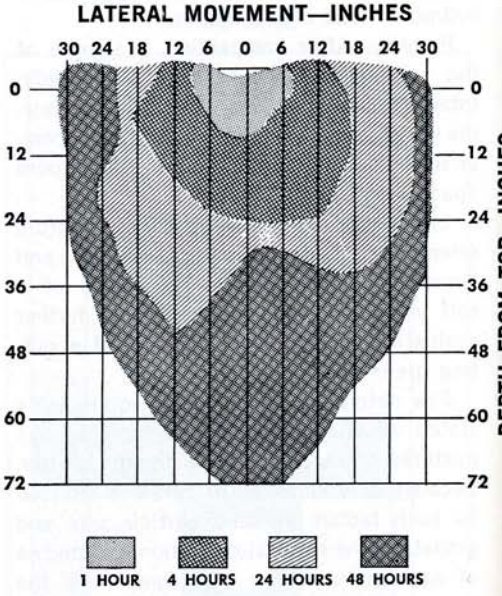


Figure 2. Infiltration of water into Yolo loam from an irrigation furrow kept filled for various lengths of time. Note that vertical movement exceeds lateral movement. (Adapted from Hendrickson and Veihmeyer, 1933.)

When the gravel layer is used beneath the putting green, it provides a medium whereby water can move laterally very easily. Thus tile can be placed just at the bottom of the gravel layer and spaced an intervals of 10 to 20 feet, depending upon the degree and direction of slope.

The layer of coarse sand used over the gravel base is for the sole purpose of preventing the soil particles from migrating downward into the gravel. This principle can be most easily pictured by an overly simplified illustration. Suppose one filled a room half full of basketballs and then poured a sack of marbles on top of them. The marbles will move down through the voids to the floor. So will small soil particles move down through gravel. In contrast, suppose the room half full of basketballs were covered with a layer of baseballs. They would remain

in a layer. Then a layer of golf balls would stay on top of the baseballs. Then if you poured the sack of marbles on top they would stay in place. Thus, if you wish to keep fine soil on top of coarse materials, it is necessary to build up with successively finer layers of material.

Ringing the Green—Some builders place topsoil around the edges of the green after the sand and the gravel are in place. They will then proceed to place the putting green soil mixture on top of the gravel and bring it to the finished grade.

There is one disadvantage to placing a heavier topsoil contiguous to the porous putting green soil mixture. Moisture is sometimes drawn out of the putting green edge because of the greater tension exerted by fine-textured soil. This disadvantage can be overcome by using something like polyethylene plastic sheeting as a vertically placed moisture barrier between the "ring" of topsoil and the soil mixture on the putting surface.

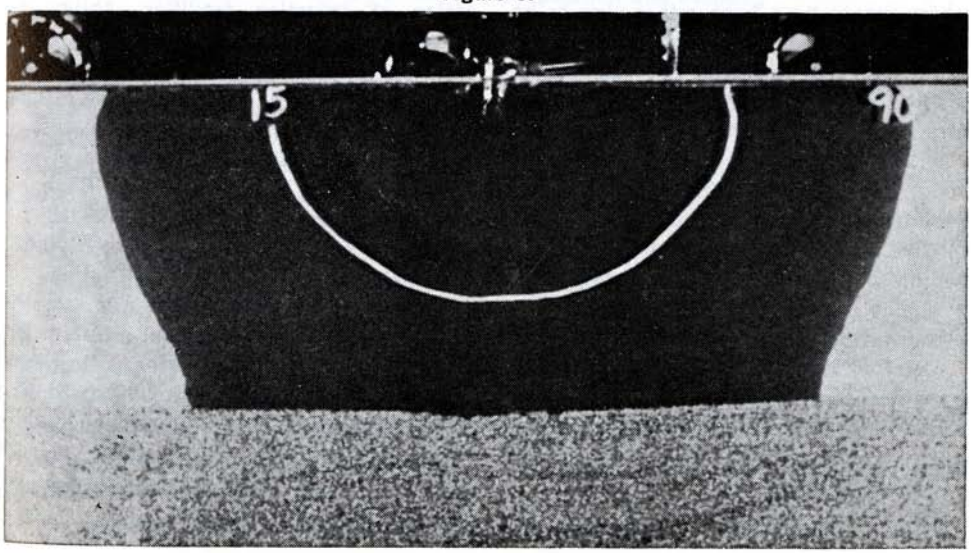
Without the use of such a moisture barrier, the edge of the putting green may dry out faster than the remainder of the green.

The Interface—Apparently one of the most puzzling of the principles involved in the Green Section Specifications is the function of the textural barrier. Figure 3 is a photograph showing that water does not move from a layer of fine soil into a lower layer of a coarser-textured soil until the fine-textured soil becomes saturated. The reason for this failure of water to readily cross the "textural barrier" is a matter of surface tension. When sufficient gravitational force (weight) accumulates, the tension force is overcome and water then drains out through the sand and gravel.

"The "textural barrier" then can be used to increase the water holding capacity of an open-textured soil. If irrigation is stopped just before the soil reaches the saturation point, no drainage occurs. On the other hand, in the case of a heavy rain, the soil will not hold too much water. It is paradoxical that the soil overlying such a "textural barrier" can be made to hold more water than it would without the gravel layer, but it cannot be made to hold enough water to be harmful to plants.

The Soil Mixture—The compounding of a soil mixture based on laboratory tests is one of the essential elements of the Green Section Specifications.

Figure 3.



In some cases greens have been built and called "Green Section Specification" greens where the builder has borrowed a formula based on his neighbor's laboratory tests. This is a dangerous practice because soils, sands, and organic matter are likely to vary widely within a community. In some experimental plots where the same sand and the same organic matter were used but where two different high clay content soils were used, a suitable mixture required 40 percent of one soil and less than 10 percent of the other.

Some critics of the use of laboratory methods have argued that one cannot substitute laboratory measurements for good judgment. How true! **But how much better is a judgment based upon measurable physical facts rather than on instinct, "feel", or visual estimation.**

Soil Covering, Placement, Smoothing, and Firming—In our experience we have found no difficulty in following this step in the method we have advocated. It may be well to reiterate that soil should be mixed "off site"; it is virtually impossible to do a satisfactory job of mixing soil materials in place on the green site.

Establishment of Turf—Because of the fact that soil mixtures prescribed are quite porous, there have been a number of cases where greens have been rather slow to become established. Frequent, light fertilization of newly seeded or vegetatively planted greens appears to be one method of speeding establishment.

In several cases these greens have been sodded. This is a satisfactory procedure **provided the sod is grown on the same soil mixture as is used in the green.** Growing sod on a heavier soil and then moving it to a porous putting green soil is an almost certain invitation to failure.

Use the "Whole Package"—The steps outlined for constructing putting greens will provide excellent results if they are followed exactly and completely. This fact has been amply demonstrated.

Equally demonstrable is the fact that going just part of the way with these procedures is an invitation to failure. A great many years of research have gone into the study of each phase of this method of construction. If one uses a heavy soil, he must either use a much deeper seedbed or he must leave out the gravel layer. If one mixes a soil that is too sandy and too deep, it will be droughty.

These are negative ways of saying that if you undertake to construct a putting green by this method, follow the instructions completely.

How Expensive?—Some clubs have been deterred from building putting greens by this method because they have thought that the construction costs will be excessive. It is obviously impossible to predict the cost in any given area because of variations in the cost of soil materials, gravel, and labor. Some ideas of quantities of materials may help in cost estimations. The following quantities of materials are required per 1,000 square feet of putting surface:

Gravel	4-inch depth—12.3 cubic yards
Sand	1½-inch depth— 4.6 cubic yards
Soil Mixt.	12-inch depth—37.0 cubic yards
Tile	approximately 100 lineal feet

Irrigation of Putting Greens

A part of greens construction is the provision of irrigation facilities. Ability to control the irrigation of putting greens is the key factor. Ideally, the job should be done altogether by hand watering. Practically, this is impossible in most cases.

Any method based upon the use of set sprinklers must have flexibility. Changes in wind direction may call for the use of sprinklers placed in several different positions. The use of at least five locations at intervals around the green are usually necessary. Locations will be dictated by shape of green and wind patterns. In addition to the permanent sprinkler positions, it is desirable to have at least one outlet where a hose may be attached. This is useful in hand showering, spot watering, and in filling in a blank in an irrigation

pattern which may be caused by unusual wind conditions.

Low precipitation rates for greens are desirable. Some automatic systems may use higher precipitation rates, but apply water for very short intervals and depend upon recycling to accomplish the wetting of the soil without runoff.

Choice of Grass

In most parts of the United States, putting green grasses are a variety of either creeping bentgrass or fine-leaf (hybrid) bermudagrass. Seaside and Penncross are the only two types of bentgrass planted from seed.

Seaside is a heterogeneous population of creeping bentgrass occurring naturally in coastal areas of the Pacific Northwest. Because of tremendous genetic variability, some of the seedlings in a planting of Seaside bentgrass will be suited to a given environment. At the same time, many seedlings fail to survive and the eventual turf is composed of several dozen of the surviving clones. Thus, ultimately greens take on a mottled appearance as the surviving clones enlarge with age.

Penncross bent is a synthetic variety created by the cross pollination of three vegetative selections of creeping bent. There is some genetic variability but not nearly so much as is the case with Seaside. The weaker types which disappear from a Seaside bent planting are not present in a population of plants from Penncross seed.

Numerous vegetatively planted creeping bentgrasses are available. Among them are Arlington (C-1), Cohansey (C-7), Toronto (C-15), Congressional (C-19), Washington (C-50), and Old Orchard (C-52). These grasses provide very uniform turf. Where they are well-adapted, they are often preferred. Their range of adaptation is not so great, however, as that of the seeded types. In choosing a grass for a new golf course, it is well to check with clubs in the same geographical location to learn their experience with the vegetatively planted selections.

Where bermudagrass is used for putting greens, Tifgreen, a hybrid arising from a cross between a selection of **Cynodon dactylon** and **Cynodon tranvaalensis** is the most widely planted single variety. Recently Tifdwarf, apparently a vegetative mutation arising from Tifgreen, has begun to find favor.

Several other bermudagrass selections are available but their use is quite limited.

Collars and Aprons

The areas around putting surfaces should be prepared carefully. This part of the golf course is maintained less intensively than the putting surface but more intensively than fairway.

Areas adjacent to greens are abused by the turning of mowers, and sometimes they are subject to additional traffic from hand-pulled carts and from caddies dropping golf bags. The grass should be of a type that will tolerate mowing to about ½ inch. In the cool season grass region, this implies the use of bentgrass. In the bermudagrass region, the area surrounding the green is usually planted to the same grass that is used on the putting surface.

Preparation and Planting

After soil is prepared and placed on greens in accordance with preceding discussions, it is firmed, raked repeatedly and watered several times to effect thorough settling. Fertilizer materials are incorporated into the surface portion of the soil in the final grading stages.

Sterilization is normally accomplished by fumigation with methyl bromide. Fumigation requires about 48 hours. The gas is injected beneath the polyethylene sheets. After the film is removed, an aeration period of 48 hours is usually sufficient to allow all the gas to escape from the soil. Greens are then ready to plant.

If greens are seeded, rates varying from two to five pounds of seed per 1,000 square feet are used. Seed is divided into two lots

and sown in two operations. The second lot is sown while moving in a direction at right angles to the direction used in sowing the first lot. Seed may be raked in lightly or covered with a light topdressing. Watering must be very frequent, with a fine spray mist until seeds have germinated and seedlings have become established.

In planting a green with stolons, rates of 2 to 10 bushels of loose packed stolons per 1,000 square feet are used. The rate of planting will affect the rapidity of establishment. Stolons are broadcast by hand over the areas to be planted. Usually a light topdressing is used to cover stolons, but some contractors use a machine consisting of a series of closely spaced straight disks to push the stolons into the loose soil.

In either operation, it is imperative that a moist environment be maintained until the stolons have established roots and have begun to grow.

Tees

The Rules of Golf define the teeing ground as "a rectangular area two club-lengths in depth, the front and the sides of which are defined by the outside limits of two markers."

In the early days of golf, an area so defined could well have served as adequate teeing area on any hole for the greater part of the golfing season. Tees then were relatively small, usually were elevated, had steeply sloped sides, and were almost square in design. In the ensuing years, emphasis was placed on larger tees to accommodate the increase in play. With the increase in size, tees were constructed with gentle slopes so that the sides and even the surfaces if necessary could be maintained with larger units rather than by hand.

While there is no set rule for the size of tees, they should be large enough to accommodate frequent change of markers and to avoid unnecessary turf wear in any one area. A good rule of thumb for tee size is a minimum of 100 square feet of usable tee space per 1,000 rounds of golf per year on par-4 and par-5 holes, and a minimum of 200 square feet per 1,000 rounds of golf per year on par-3 holes subjected to iron play from the tee. For tees on par-3 holes played with a wood, the same rule of thumb applies as is suggested for tees on par-4 and par-5 holes.

Shapes

Tees may be built to any conceivable shape but the design should be such that it fits well with the existing terrain and is easy to maintain. Multi-level, tiered, or abruptly elevated tees seem to have lost favor in popular and practical design, which has been influenced greatly by today's heavier use of the course. There appears to be much room for improvement in the general design of tees. Many of the newer tees are long, narrow, and rectangular in shape; in fact, some are so long they are sometimes affectionately referred to as "The Landing Strip." Unfortunately, the average player seldom likes to tee off except from the front third of the long tees, and such tees require maximum maintenance for minimum usage.

Tiered or multi-level tees also are dwindling in popularity because much valuable teeing area is lost in between tiers. Some of the more interestingly shaped tees are circular, semi-circular, "L" shaped, "T" shaped, or "U" shaped. While there is no limitation on shape or design, tees should not restrict the flow of traffic nor create areas of concentrated wear. They should be designed so that all parts of the tee may be used equally well and that traffic will be dispersed as widely and uniformly as possible.

Location

The location of a tee with respect to the flow of traffic and its relation to surrounding objects is important. No tee should be placed in the direct line of traffic from one facility to another, and the flow of traffic should be around rather than across the tee. Foot and car paths with plants of one sort or another subtly interspersed and strategically located to guide traffic is often helpful. This is especially critical in and around the clubhouse, where ugly and untidy paths can develop which detract from the overall beauty of the club grounds.

In the case of small tees, tees under repair, or very heavy play in winter and/or summer, alternate teeing areas may be required. Alternate teeing grounds, during periods of adversity, can distribute wear over a wider area, thus reducing wear and tear on the regular tee.

Tees ordinarily should be located in areas not confined by trees nor shaded from direct sunlight for any period of time. Trees should not be planted so close that they will compete with grasses for water and soil nutrients. Hedge rows and other ornamental plants normally are not desirable around tees for the reasons stated, and also because usable teeing area is considerably reduced. Hedge-like plantings do have value when used near the tee as a screen to block out traffic noises, untidy buildings, or the view of unwelcome spectators.

Women's tees are receiving more attention, and rightly so because of the increased use of the course by ladies. All of the considerations which go into the construction of the men's tees should also be employed for the ladies' tees to make a really adequate course. One exception might be in tee size. Because of the difference in ferocity with which men attack the game, ladies could get by with smaller tees, possibly one-half the size suggested for men. Certainly the postage stamp tees of the past are no longer adequate to accommodate ladies' play at most courses.

Construction

Next to greens, tees and aprons are the most intensively maintained areas on a golf course. The trend today is directed toward tee maintenance and management programs similar to that of greens. There is a growing tendency to mow tees with putting green mowers, to remove grass clippings, to cut close and frequently, to apply quantities of fertilizers and disease control materials that are applied to greens and generally to groom tees as neatly as greens. To pursue the intensive maintenance required demands that most of the major considerations afforded greens in construction be built into tees also.

The tee topsoil should be a prepared mixture of sand, soil, and organic matter in a ratio which insures a friable soil with good internal percolation and drainage. The prepared soil should be placed on the site at a settled minimum depth of four inches, and preferably should be sterilized before seeding to insure freedom of weeds. Lime and fertilizers should best be applied at this time and mixed into the four-inch topsoil surface. The need for limestone should be determined by soil test, while nitrogen, phosphorus, and potassium are supplied in amounts normally required for turfgrass establishment. All nutrient elements should be thoroughly and carefully incorporated into the topsoil. The topsoil must be allowed to settle or it must be firmed well by other means prior to planting the grass. If there is not adequate time to allow for natural settling, then it is necessary to rake and roll several times over, also to do some "footing." This is accomplished when workers walk over every square inch of the new soil, assuring against uneven settling of the tee as the turf develops.

Tee soils should not hold water excessively, or they will suffer during periods of traffic or weather stress. As with greens, good internal and surface drainage is required and should be provided for during construction. Good surface drainage requires that pond-like depressions be averted

and that water drains away from the tee quickly in broad, shallow sheets rather than in narrow run-off channels.

Normally, a very slight descending pitch from front to rear is desirable. The pitch must allow for quick surface drainage and yet be subtle enough so that the player will feel he has a level stance. A slope of one to 1.5 percent will prevent surface water from ponding.

If tees are multi-level, it is extremely important that the rear-most portion of each level be pitched slightly to right or left so that surface water does not collect between levels. Ponded water not only detracts from the beauty of a tee but makes the tee uncomfortable underfoot and will injure the turf if the water remains there any length of time.

Good internal drainage is necessary to allow water into and through the soil so that roots receive the proper amounts of moisture. Soil types greatly influence internal drainage, and if the subsoil is not porous then tile drainage lines may be required. Four-inch tile lines would be installed in the same manner as for a golf green, with the outlet placed in some out-of-play area away from the normal traffic pattern.

Irrigation

Principles of irrigation apply to tees in much the same manner as those for other areas of the course. The quantity of water used, the frequency and the rate of application must all be adjusted to meet the needs of the turf as well as the specialized playing conditions.

The major difference in tee irrigation is that it is geared to the minimum requirement so that tees will be kept on the dry side. Tees should be watered at periods which will allow the longest possible time between irrigation and heaviest play.

The tee must have a reasonably dry surface to avoid unnecessary turf damage and provide a firm stance for the golfer. With larger tees, perhaps sections of the tee could be irrigated on a schedule so that only drier areas could be utilized to conform with heavy play schedule and the movement of tee markers. Over weekends and on days when heaviest play is expected, it is desirable to set the markers on areas conditioned to the dry side.

Most courses today have underground lines leading into tees for irrigation purposes. Quick coupling systems have been most popular, but the trend toward semi- and fully automatic systems in new course construction is on the upgrade. Hoses and movable sprinklers appear to be on the way out because of the labor requirements and the difficulty in completing irrigation in the required pattern without players or caddies moving them or turning them off prematurely.

Choice of Grass

The choice of grass for tees will hinge upon several factors. The turf must allow for a firm stance; it must be tight and dense but still easily penetrated by a wooden or plastic tee; it must be cut close so that the advantage of teeing up to each individual golfer's liking is a real one; it must be tough enough to recover from golf club and traffic injury in reasonable time; it must have spreading or creeping qualities in order to provide a uniform and smooth-looking and smooth-playing turf; it must be attractive, and it must be groomed neatly for golfers to care for it as a valuable asset to their golf course.

There are numerous selections to choose from but those used for tees seem to be narrowing down to the very same selections being used for greens. These are mostly bentgrass selections for northern courses and the fine-leaved bermudagrass for southern courses. In the North, the creeping strains such as C-1 Arlington, C-19 Congressional, C-7 Cohansey, C-15 Toronto, C-52 Old Orchard, Nimisila, and Penncross are widely used. All mentioned, except Penncross, are vegetative strains and are planted by means of stolons. The usual

rate of stolonizing varies from four to eight bushels per 1,000 square feet. Penncross is a seed variety and the rate of seeding is generally from one to 1½ pounds per 1,500 square feet.

Other means of establishing turf on tees is by means of sodding or by spreading aeration cores gathered from greens aeration. The latter technique is mostly utilized in nursery establishment but it has been done successfully on new tees.

Sodding is not normal practice in new course construction because of the comparatively high cost of sod and, oftentimes, the local unavailability of the type of sod desired. Sod is used normally to renovate tees when weaknesses develop after years of play.

Nursery sod is grown on the course by the superintendent for use in emergencies, for divot repair, to renovate, or to sod tees which the superintendent subsequently alters or constructs himself. Normally, it is desirable to establish a tee nursery on a prepared soil similar to that used for tees on the course. Using similar soil prevents problems of layering. Layering is detrimental to a soil profile because it restricts or inhibits root, water, and nutrient penetration to a desirable depth.

Other grasses used for tee cover are Merion bluegrass, Kentucky bluegrass, creeping red fescue, Seaside—Astoria—Highland bentgrasses, and **Poa trivialis** on courses where cool-season grasses principally are grown; and bermudagrasses and the zoysiagrasses where warm-season grasses are encouraged. The rate of seeding of the grasses listed will vary from 2 to 5 pounds per 1,000 square feet, depending on the choice of mixture.

Fairways

The clearing of land for fairways makes up the bulk of required work in golf course construction since fairways comprise the largest fine turf acreage on the golf course. In some cases the task requires monumental effort in tree and stump removal, rock clearance, stone pickup, or blasting through ledge prior to seedbed preparation. In other cases the work required is nothing more than routine contouring and smoothing the terrain prior to sowing the seed. In every case, however, there is need to adhere strictly to all the cardinal agronomic requirements in the construction phase in order to insure that there will be a minimum of built-in headaches to contend with as the course matures.

While the term "fairways" is not specifically defined in the Rules of Golf, they really exist, a fact to which many a golfer will attest. How important are fairways in the total picture? Opinions may vary widely.

If we were to examine the perfect game at any regulation par-72 course, strokes would be divided as follows: 18 shots where the player is allowed to tee the ball, 18 shots from the fairway, and 36 strokes on the putting green. The 18-shot allotment for fairway play takes on added importance when examined in this light. It stresses the importance of the exacting requirement on the fairway lie for skillful play, and so construction of fairways should therefore be perfect.

There should be no dips or depressions, no pot holes, no furrow rows, no buried fence rows, and no buried "elephants" that belatedly and unfailingly one day expose it for the "white elephant" that it is. This doesn't mean that fairways should not have rolls, slopes, and contours, for these are important indeed to the playing skills of the

individual; however, all of these features should have a finished grade of gentle smoothness. This is no easy task since fairways comprise some 30 or more acres on a regulation 18-hole course.

True total acreage depends on the mowing pattern of the club in question. Some like to make fairways narrow for keen play, while others prefer to mow everything in sight as fairway. In original construction, the area in the direction of play from tee to green for a width of 50 yards should be graded to perfection. This is normally thought of as the area of fairway play and it is this area that should receive exacting attention. The area to either side of this 50-yard designation would be considered as rough and need not receive anywhere near the attention in grading given to fairways. Fairway lies should excel, while lies in rough should inflict some degree of penalty.

Inspect Land Carefully

Rarely if ever is land turned down as unsuitable for golf course construction. If the requirement for fairways is to be as exact for a perfect par round of golf as implied, then it follows that not all land is suited to meet the required specification. Land, therefore, should be examined carefully prior to purchase to insure the certainty of excellent fairways.

The first step in establishment is to stake-out the line which designates the center of each fairway. Fairways should best be oriented so as to minimize glare from the rising and setting sun. Then all vegetation is cleared out to a minimum of 75 feet on both sides of the center line. Normally at this time the necessary rough clearance also is done, and this would mean that trees may be felled and stumps removed except for specimen trees and trees situated in strategic areas. The latter would include trees that would accent the dog-leg holes, or force play to one side or the other, according to the golf architect's plan.

Plans vary widely. In fact, at a few courses trees have been placed in fairways to make specific holes more challenging. Trees may be placed near approaches to greens and may make a decided difference in the strategy of play. There are trees that narrowly line the beginning of fairways and give the golfer the distinct impression of hitting "out of the chute", and this adds to the difficulty of a good hole.

Which trees do you save and which do you destroy? A competent architect will go through each projected fairway and carefully mark trees that should be saved. If there is any question about a limited few, it is always best to save them to see how they enter the play of the hole. They can always be dropped later if so decided.

The value of some tree-lined fairways is indisputable — a priceless feature that older courses normally attain as they mature. If this feature can be built into a young course, its playing quality in early years is greatly enhanced and the course will mature far more quickly than a course where no trees are saved.

Removal of Trees

In clearing, trees are felled and stumps are removed and burned. If the new course site happens to be near a lumber mill, there may be an opportunity to profit by by the sale of larger trees. However, in most cases new sites are too distant to transport trees economically and so they are destroyed. The usual technique is to pile and burn trees, stumps, underbrush, and any other vegetation in craters dug at convenient 'vantage points throughout the property.

While there are several techniques in burning, the most common is to intersperse old rubber tires at points throughout the "mountains" of felled trees, and ignite them. The tires burn fiercely and are the ideal starter for burning trees of any size and dimension. In selecting burning sites it is important to stay far enough away from trees that are to be kept, so they are not maimed or destroyed accidentally by catching fire.

After trees are completely burned, craters are filled and graded prior to seeding. Because it is possible that the organic residue remaining may settle eventually, it is preferable to dig the craters in out-of-the-way rough areas, rather than areas that eventually will be made into fairways. Where craters cannot be dug, the burning usually takes place on the surface of proposed fairway or rough areas.

Stump holes also require soil-fill and tamping so that they do not settle and cause future bumpiness of fairways. It they are not too numerous or too deep, it is possible to fill and tamp holes when grading fairways prior to seeding. These operations are very important on deeper holes, which settle most if left untamped. The rule of thumb is that most soils settle approximately two inches in 12.

Clear Away Debris

The next operation in clearing is to gather stones, rocks, and surface debris. It is best to haul as much as possible to out-of-play wooded areas, or if land is limited, bury them in the crater holes dug for tree burning. If stones, rocks and surface debris are buried where turf is to be established, it is most important to use a soil cover of depth sufficient to preclude excessive drying. The preferable depth is a uniform settled cover of eight inches total soil, the top four inches of which would be topsoil.

Should the land be especially stony, a great deal of time will be required for clearing. It is usually necessary to go over each area several times to do an adequate job. Mechanical rock pickers are used to remove larger stones, and mechanical rakes, such as the York rake, are used to collect and windrow rocks. No mechanical pickers do such a thorough job, however, that hand work is eliminated entirely.

The better the cleanup in construction, the fewer the man-hours will be required the first few years after the course is put into play. If a thorough job is not done, then it is most important to plate fairways with soil to cover remaining stones, and to mulch fairways after seeding to minimize erosion. These practices reduce the chance of rocks working their way to the surface in excessive numbers.

Drainage

Sometimes fairways are constructed over peat or swamp bogs. If not first improved by drainage (surface and internal) in construction, such fairways will remain bumpy as long as the course exists. Only if the bog is stabilized will fairways be satisfactory. The proper way to construct over bog is to drain, stabilize, and then cover it with topsoil to a settled depth of 4 inches minimum. Adequate drainage insures a minimum of extremes in soil expansion and contraction with wet and dry weather. Normally, bog areas do not make excellent fairways and so should be avoided if at all possible. Because of the many variations in situations involving bogs and swamps, the club should secure the services of a competent drainage engineer.

One of the important considerations in construction is depth of natural soil on the site. If the profile is deep and uniform, fewer problems result in shaping up fairways. On the other hand, if the natural soil is skimpy, careful probing and a studied determination of its actual depth on all land belonging to the club is essential. In such a situation where topsoil is scarce and where more than four inches of native soil is found, all in excess should be scraped and stockpiled. Farm-type soil augers or putting green soil probes are most satisfactory for determining soil depths.

Where natural soil is shallow, work required in seedbed preparation will have to be more exacting to assure that some soil, however meager, is spread uniformly for a seedbed. In most such cases, it is economically impossible to purchase topsoil for entire fairways. Costs would be staggering.

Another requirement of paramount importance on a shallow soil is to provide a mulch to insure that the seedbed, once

prepared, remains stable through turfgrass establishment. These items are of not only initial monetary importance but also in the subsequent playing quality of the course.

Treatment of natural waterways and drainage courses

Natural waterways or drainage courses through the golf course property will be important factors dictating design, construction, and future maintenance. In the case of constantly flowing creeks or rivers, the golf course designer will usually employ these features in planning the strategy of the course. They will be left open and bridged at appropriate points.

The banks of brooks, creeks, or rivers are subject to a variety of treatments. If they are particularly picturesque, the esthetic value of natural appearance may override considerations of maintenance. In many cases, however, the banks of streams are unsightly as well as difficult to keep. If so, it is well to straighten such streams in order to facilitate water flow, to protect against erosion by the use of stone or wood pilings, and to slope the upper banks in such a way as to permit mowing up to the edge of the channel. Each case will present an individual problem and no definite rules for treatment can be prescribed. Such situations are deserving of much forethought, because it is this kind of area that will require an extraordinary amount of maintenance labor in the future.

In the case of very small continuous or intermittent flow within a rather large natural channel, it is usually possible to take care of the regular water flow by using a buried concrete pipe. Sizes up to about 24 inches usually are economically feasible even for fairly long runs. The larger channel that carries only storm water can then be sloped so that mowing equipment can operate through the swale under normal conditions. Treating small streams in this way usually will afford a maintenance saving in future years sufficient to justify the initial cost of construction work.

Grading to accomodate operation of maintenance equipment and golf cars

There is no better time than the construction phase to plan for the inescapable problem of increasing golf car use. With careful study, the necessary road layout and grading could be done even if the finished surface is completed later. With good early-stage planning, little or no interruption should be necessary once the course is opened for play. Here, too, it is important to construct roads with gradual slopes for smooth golf car movement, golf car passenger safety, and easy maintenance of road beds.

While considering golf car roads, it is also important to plan roads for movement of vehicles and equipment for course upkeep. Where the golf car and maintenance vehicle roads can be combined for dual use, a definite bonus in savings and aesthetics is realized. If this is not possible, maintenance roads should preferably be cut through wooded areas, inconspicuous to players, providing as nearly as possible an uninterrupted picture of unscarred landscape.

Drainage and Irrigation

Sizeable areas are difficult to drain perfectly. The easiest and best time to make the obvious drainage improvements is in the initial construction phase. Once the grasses are planted, everyone has qualms about tearing it up again to make the necessary improvements. When terrain is unsuited to good natural drainage, it usually is costly to install workable drainage patterns throughout. In a few cases, a simple swale can do the trick; in others, it may take considerable tile to move the water away effectively. If tile is required in any quantity to do the job adequately, or if large-sized tile is required for culverts, these can be very costly initial items.

It is always wise to inspect a potential course site during rainy seasons to check out the natural drainage patterns and the severity of the problem. If there is any

question about the drainage qualities of any soil or area, the local United States Department of Agriculture Soil Conservation Service can provide the answers without charge. They should be consulted in the early stages of site observation, preferably before the land is permanently acquired.

Progressive golf course superintendents agree that irrigation and drainage go hand-in-hand, and this is a fact of life for all turf managers. If you plan fairway irrigation, it is imperative also to provide for excellent drainage. Large acreages never drain uniformly, as soils seldom are uniform throughout.

Where tile is required, it is possible in some cases to lay it and the irrigation pipe side by side in the same trench. While the irrigation ditching equipment is available, separate drainage laterals can be dug, where required, with a minimum of effort in the initial stages of construction. Since both irrigation and drainage lines normally are placed at depths of 18 to 36 inches, this expedites and reduces the total project workload. Considerable settling takes place over trenches, and so they must be properly tamped and leveled prior to seeding.

In the past, irrigation lines were normally dug down the center line of each fairway. However, now that automatic irrigation systems have become more popular and multi-row trenching is now a reality, it should be easier to cut drainage patterns into or away from the irrigation trenches as the plan dictates.

New courses would best consider the installation of a complete irrigation system during initial construction. It is always costlier both in funds and player anguish when the decision comes as an afterthought.

For fairway and rough drainage, there are no set patterns; where the problem exists, drainage improvement is required. This can be minimal or excessive, depending upon terrain. If the land is blessed with good surface drainage, a minimum of subsurface drainage normally is required.

In a discussion of grading for surface drainage, on land that has been undisturbed except for surface cultivation many natural drainageways will have been developed. If the golf course is made to conform to natural terrain, the problem of grading to provide surface drainage is usually much less severe than in cases where a great deal of earth-moving occurs. Large earth-moving jobs invariably create drainage and erosion problems, and consequently much more attention must be accorded this matter.

In some cases French drains will do the job adequately. This method prescribes a narrow trench (2" to 4" wide) dug to the required depth, but usually six to 24 inches deep, and backfilled with gravel of ½ to ¾ inch size. This provides an open channel for water to flow to prescribed outlets. If these drains are cut in areas of play, place grass clippings, straw, or coarse sand over the gravel in order not to impede natural flow of water through the gravel to the outlet. In time turf will spread to cover these lines. If sod or soil is placed over the gravel, the natural flow may be restricted and the effect of the open drain impaired. French drains are a simple and most effective way of draining soils economically.

Catch basins are sometimes effective where other methods of collecting water rapidly are impractical. A catch basin is normally dug in some out-of-the-way area, and backfilled with stone and gravel. If it is possible to construct the catch basin in an area where impervious soil layers can be penetrated to areas of good vertical drainage, this can be effective. In some cases, the construction of a holding pond could be classified as a catch basin in its broadest sense, but in this case the water is trapped for use for irrigation, aesthetic, or strategic purposes.

Outlets at any drainage point are normally stabilized so they do not wash out when accomodating flash floods and heavy water loads. Concrete forms are usually cemented around all outlets, because they are least vulnerable to damage by natural causes or vandalism.

The final fairway seedbed preparation is done with discs and mechanical rakes. Plows are seldom used in rocky areas for obvious reasons. The usual seedbed specification that most strive for is a minimum of four inches of **native** or **natural topsoil.** We prefer this reference to this upper stratum because topsoil in golf course management language normally means an artificial preparation, a mixture of soil, sand, and organic matter bought and brought to the site. Therefore if the plans call for soil to be purchased, it is referred to as topsoil; if the specification calls for using soil on the site, it should be termed native or natural topsoil.

Once the soil is loosened, then mechanical rakes and rock pickers go over these areas several times in order to clean up all debris and rocks down to the size of a golf ball. Beyond this, hand picking is required, and so this is where the site selection begins to tell whether the choice was a wise one or not. The more hand work required, the more expensive the total costs will be.

In the final discing and raking operations, it is always wise to add limestone, phosphorus, and potash if the soil requires them. Somewhere early in construction, soil samples should be taken and sent to a competent soils laboratory, usually the state agricultural experiment station, for chemical analysis. Samples should be representative of the total fairway and should be taken from several areas, mixed, and made into one composite sample for each fairway. It is best to test all fairways and add required elements in the beginning.

Limestone and phosphorus especially are important in the early stages of seed bed preparation because these nutrients are relatively immobile in the soil. If placed on the surface they will remain there and form a layer. Nitrogen and potash, on the other hand, may be added later since they have the faculty of leaching through soils rather quickly. Normally a complete fertilizer, one containing nitrogen, phosphorus, and potash, is applied to the surface at the time of seeding and usually supplements the elements mixed into the soil bed. Materials mixed into the seedbed are usually incorporated intimately to a depth of approximately 4 inches.

Seed mixtures for fairways will vary with location. Normally in the Southern areas the bermudagrasses are used exclusively, the select strains preferably. These are propagated by vegetative means (planted by stolons). Although bermudagrass can be planted by seed, this practice is giving way to widespread use of improved select strains available in the form of stolons.

In the Northern regions there are two basic mixtures used in seeding fairways. One is a mixture of Kentucky bluegrass, creeping red fescue, and bentgrass; and the other is a mixture of several bentgrasses. The basic difference in the end result is that the bentgrasses will result in a tightly knit turf, one that can be cut close. The professional and better golfers prefer this type of turf because the bluegrass-fescue-bentgrass combination generally cannot thrive when mowed less than 1¼ inches.

The percentages for a quality combination seeding would be approximately 35% Kentucky bluegrass, 60% creeping red fescue, and 5% Colonial bentgrass. The Colonial bentgrass may be of the Astoria or the Highland variety. The latter seems better adapted to the southern portions of the bentgrass range, while the Astoria is preferred for the northern portions. The bluegrass may be a mixture of select strains such as Merion and other Kentucky bluegrasses. The fescue may be a mixture of such strains as Pennlawn, Illahee, Ranier, or Chewings. The seeding rate is normally between 125 and 150 pounds per acre.

In most parts of the United States the best time for seeding all cool-season grasses is in early to mid-August where irrigated, and from late August through September where unirrigated. One possible exception to this is in desert and mountainous areas where extremes of temperature occur during

early fall. In some such cases, spring seedings appear preferable. If seeded at any other time, and in spring especially, it may be necessary to add a "nurse" grass, one which would germinate quickly to make a turf cover to stabilize the soil until the permanent grasses come through.

The theory behind the so-called "shotgun seed mixture" is that it may provide some grasses suitable to any conditions of soil and topography, and those suited to a particular ecology will persist. For example, on low, moist areas, the bentgrass will stand out; and on the high dry areas the fescue should grow stronger, while in the in between areas the Kentucky bluegrasses will tend to make its strongest bid.

This mixture has the disadvantage in that bentgrasses cut at 1¼ inches tend to become puffy and soft and do not afford as good fairway lies as close-cut bentgrass. There is a further problem in the establishment of a uniform turf from this combination because of the great differences in size of each seed. Bentgrass seed is minute, bluegrass intermediate, and fescue is a large-sized seed. Because of these wide differences, it is preferable to sow each separately to insure a uniform cover.

Where close-cut bentgrass fairways are desired, the mixture most commonly used is one that is predominantly Colonial bentgrass. The same rule applies regarding Astoria for the northernmost and Highland for the southernmost areas of bentgrass adaptation. A good bentgrass seed mixture for fairways would be 60 to 75 percent Astoria or Highland and the remainder divided between Seaside and Penncross, seeded at the rate of 75 pounds per acre.

In the northern portions of the Midwest, **Poa trivialis** has been used with bentgrass mixtures. **Poa trivialis** will tolerate relatively close mowing and thrives in moist environments. While this species has not heretofore been considered to be of great importance for fairway turf, its addition to the list of available species should be considered.

For good bentgrass growth, the pH level need not be as high as for bluegrass fairways. Therefore not so much limestone is required in the seed bed. A pH of 5.5 to 6.0 appears preferable for bentgrass, while bluegrass makes its best growth at 6.5 or higher. If a "nurse" grass is needed, redtop should be used because its growth habit is more nearly similar to bentgrass than are the ryegrasses.

There is great need for new and improved grasses for northern fairways. Here research must point the way, and considerable work is needed. In essence, what we need for northern fairways is a grass that will grow, look, and play like **Poa annua** in May, but one that will not be subject to summer failure. A bentgrass with stiffer blades, one that compares with the stiffness of bermudagrass, would be most desirable.

The possibility of the return of predominantly creeping red fescue fairways is not beyond reality. Creeping red fescue was once considered the best fairway turf available, and when seeded with Kentucky bluegrass it usually predominated under the management programs of yesteryear. This was before the days of high fertility and complete irrigation systems in fairway management programs.

With more and more restrictions on water use today, and certainly into the future, there is good argument for the return of a predominantly creeping red fescue turf. Another factor in its favor is the improved Pennlawn strain now available. Undoubtedly, as more and more improved strains are developed through research, this species will be considered with renewed interest. With improved management and advanced techniques, creeping red fescue fairways could well fit into the future picture on northern courses.

Bunkers

The design of bunkers is governed principally by the requirements of play, topography of the area and aesthetic considerations. From the standpoint of maintenance, however, several other factors must be taken into account. The first thing to be considered is the effect of the design on mowing. Nearly all golf courses have bunkers which require hand mowing to some extent, and this probably cannot be avoided, but, if thoughtfully designed, bunkers can require a minimum of hand mowing.

Fairway bunkers or those in the rough immediately adjacent to the fairway should be so designed that mowing can be accomplished with the standard gang units used for fairways or roughs. Bunkers located within the confines of the fairway should be surrounded by an apron of rough, for two reasons. First, if this is done, the area around the bunker will not require the intensive management necessary for fairways; however, these areas should be maintained neatly. Secondly, sand blasted out of the bunker onto the surrounding turf will not cause the rapid deterioration that would be inflicted on closely cut turf.

For fairway or rough, the use of grass hollows should be given careful consideration. If properly designed, they afford the desired test without the additional maintenance required by sand bunkers. Grass hollows should be nothing more than gradual depressions as far as the actual feature is concerned, but provision for drainage should be allowed. Mounds or hummocks may and should be used, but slopes should not be so severe that gang mowers cannot be used.

Mowing

By far the greatest mowing maintenance problem occurs around bunkers in the immediate vicinity of the green. Certainly they must be kept in a neatly manicured condition, and this requires increased mowing. Once again, turf areas bordering the bunker should be maintained at rough height, and design should allow for this.

A common tendency is to position the bunker flush against the green or collar. This causes great difficulty in mowing of both the green proper and the narrow area between bunker and green. Sand blasted out of such bunkers damages mower reels and bedknives, and after a period of time sand build-up on the edges of such a green will cause a droughty condition, and thus weak turf.

Bunkers located adjacent to the green should be positioned so that there is at least 6 feet between the near edge of the actual trap and the outer edge of the collar. This would facilitate cutting with a triplex or similar mechanized equipment; blasted sand would be less of a problem, and green mowing could be accomplished with greater ease and safety. In addition, the higher cut around the bunker would tend to accentuate both the sand and the green.

Steep-flashed banks within the bunker are frequently desirable because of the need for visibility, but they present a problem of sand stability, and many prefer to turf such banked areas down to sand level. This causes mowing difficulties if the banks are too steep, and it becomes necessarily a hand operation. It may also result in a hidden bunker. Whether hand mowing of steep banks or stabilizing sand on them is more of a problem is a matter of conjecture. However, if slopes are not severe and mechanized mowing can be accomplished, turf should be more desirable than sand.

Drainage

Design of bunkers affects drainage not only within the bunker but the area surrounding. This is perhaps a question of location more than any other single factor. Bunkers are sometimes necessarily placed within surface drainage flow areas. If this

must be done, care should be taken that drainage into the bunker does not occur. With proper grading and the use of swales, drainage water can be diverted around the bunker and away from areas in play. Don't forget the point that the surrounding area should be drained, too — the bunker build-up should not impede or restrict flow of water.

Drainage within the bunker is of prime importance from the stand-point of both play and maintenance. Poorly drained bunkers hold water for days after heavy rainfall or irrigation, and even after the water disappears the sand is heavy and difficult to play from. Poorly drained bunkers promote washing or movement of sand from higher to lower areas. Finally, poorly drained bunkers always appear dirty due to the seepage of soil particles up to the sand surface.

This is strictly a question of design and construction. No degree of maintenance will alleviate the problem. Wherever possible, sand surfaces should be level or very nearly so, to minimize water flow. Where large bunkers are required and proper grading cannot be done, terracing or stepping of sections should be utilized, the areas between the sections being turfed.

In many cases, tile drainage must be used to eliminate water build-up in bunkers. If the bunker is large and cannot be tiled completely, tile should be placed in or about the lowest point. Slope of the bunker floor should be only enough to allow the water to move. Anything more will cause excessive sand movement.

Requirements of play and aesthetics frequently cause areas adjacent to bunkers to be raised or mounded. This affects not only mowing maintenance but also the growth of acceptable turf. Generally, the grass on these areas is thin, bunchy, and quite unsuitable for play, especially if no irrigation water reaches the area. The reasons for such poor turf are poor soil and poor design. The tops of these areas are almost always nicely rounded, causing constant exposure to sun and wind. They are almost always parched. The sloping sides are usually too steep, allowing water to run off too quickly. The soil has little chance to absorb water, and in some cases soil is even washed away. If tops were slightly flattened and slopes more gradual, raised areas might be kept in a more acceptable condition.

All the points mentioned so far relate directly to maintenance and therefore the budget. Obviously golf would suffer without sand, and golf courses would lose some of the beauty and contrast provided by neat, clean bunkers. However, if poorly designed, bunkers require more maintenance than can be justified, and they become an unfair hazard as well as an eyesore. As a general rule, bunkers should be designed to allow for maximum mechanized maintenance, and this is especially pertinent to mowing and edging. They should be designed to afford minimum sand movement. It is far easier to rake footprints from sand than to move large quantities of sand by hand.

Proper drainage reduces "cementing" of sand particles and thus the need for more frequent raking. Proper location of greens bunkers minimizes the amount of sand blasted onto the green. This eliminates the damage to mowers and the time required to repair them. These are just some of the ways in which design affects maintenance costs, but it is rather obvious that bunker design has a substantial impact upon the budget.

Irrigation

Location of bunkers affects irrigation of greens in two ways. First, with the increasing use of fixed-position sprinkler heads, it is important that the heads be placed where they deliver maximum water to the turf and minimum water to the sand. If bunkering is too extensive this is impossible, and significant amounts of water are wasted. If part-circle heads are used, turf surrounding the bunkers receives little or no water. Secondly, sand blasted onto the green builds up and causes a perennially

droughty condition. These areas require more frequent and heavier irrigation. This makes uniform irrigation by fixed heads impossible.

The idea of bunker irrigation has recently entered the picture, and perhaps in the future this will become common practice. Most will agree that unsightly areas adjacent to bunkers are an eyesore as well as providing poor lies for play. Without some form of irrigation, it is nearly impossible to grow acceptable turf on these areas. Edward J. Casey, when Superintendent at Baltusrol Golf Club, Springfield, N.J., designed and installed an irrigation system specifically for bunker areas. Using plastic pipe and small pop-up heads which deliver 1.5 gallons per minute, the system irrigates **only** the turf while the sand remains dry. The heads are placed 12-14 feet apart and are operated in groups by manual control. Aside from providing adequate irrigation, the system presents little or no obstacle to play or maintenance.

Traffic Flow

Location of bunkers definitely affects traffic flow, especially in the vicinity of greens. One must remember that these are limited areas and traffic is extremely concentrated. Bunkers located near greens should be placed with consideration to entrance areas and departure areas. The second area is generally governed by location of the next tee, usually somewhere to rear or to either side of the green.

Frequently, bunkers placed in these areas serve little function other than providing color and texture contrast. Much of the desired contrast could be accomplished by height of cut alone, or in conjunction with grass depressions.

Because of growing demand for closer mowing in apron areas, the architect is required to use sand extensively as a means of framing the green. Framing or contrast could be accomplished by the use of specimen trees and careful positioning of fewer bunkers together with increased height of cut. This would also alleviate the problems encountered in irrigation and mowing, even though increased mowing would be necessary. Remember, most mowing is a mechanized operation, and sand raking is almost solely a hand operation.

Fairway bunkers most frequently are not really fairway bunkers at all. They are rough bunkers. Why have a bunker at the edge of a fairway or in the rough? This prevents the ball from entering the rough, which is itself a test if it is maintained as rough. The need for framing can be fulfilled by shaping or contouring fairways, placement of trees, and the use of gradual mounds or hummocks.

The role of sand in this great game is clearly understood, and it is certainly desirable, but it should be used more discriminately. Sand can be used to enhance both play and course beauty without compounding maintenance problems.

The Rough

The rough, more than any other feature, serves to set the overall character of a golf course. It is a portion of the course where, hopefully, only a small part of the game is played. Yet it provides the background, it influences other course features, and very often its character adds significantly to the score of the player who strays.

Because there is no standard, the type and quality of rough varies more than any other course feature. It may be dense woods, sand and shrubs, or simply tall grass and weeds.

The rough, as the term implies, is an area of a golf course where a player expects his ball to find a lie that will inflict some

degree of penalty. Roughs therefore play an important role in golf, yet they are without question the most neglected turf areas on most courses. This neglect begins in the construction phase and lasts through the life of some clubs. Roughs generally receive what is left over after every other turf area is taken care of, and this usually results in the stepson treatment. And so, like Topsy, it just grows!

Perhaps the fault lies in the fact that almost everyone concerned with golf course management thinks of greens first, tees second, fairways third, and roughs last, in order of turfgrass importance. The sad fact is that the gap between third and fourth places is more widespread than these standings would indicate. Greater emphasis on the importance of rough areas to skillful golf and to the toughness of a course begins with construction, for it is here that the course is born, and the rough is an integral part of an architect's brainchild.

The rough, like fairways, is covered in the Rules of Golf only as part of "through the green," and this fits it nicely since there is no set requirement, no rigid standard for roughs. They will vary in many ways but they are almost universally defined by height of cut. This cut will vary from 1½ to 4 inches in height where manicured, and beyond this where left unmowed.

Roughs can be found in front of greens or occupying portions of fairways, but normally they are placed on each side and parallel to fairways and around greens. Their lines are sometimes straight and sometimes contoured to accent target areas, contours in terrain, or to increase the difficulty of specific holes.

Areas of rough found on each hole vary widely. Some courses have trees adjacent to fairways with little or no grass rough between; some courses have several yards of rough on either side of each fairway. Just how this works out at various courses depends upon a number of factors—the amount of land available, topography, tree and bush cover, other vegetation, and water on the site (ponds, lakes, and brooks). If total acreage is limited, roughs will be the first portion of the course to be allotted less space.

Fair To Play

Roughs need not be perfectly level; in fact, they should be rough graded, yet fair to play. There is great leeway for the imagination to run rampant. Roughs may be mounded, sloped, trapped, and treed, and it all has to be in keeping with the strategy of each hole.

In the early days several hard-to-maintain features were built into the rough areas, such as the lumps referred to as "chocolate drops". These have since largely gone but there is room for some imagination in the use of mildly sloped mounds strategically placed in select areas so as to increase the test and the penalty in roughs.

Too often the roughs are just as smooth as fairways and little if any penalty is inflicted. In fact, there are golfers who deliberately play into the rough because of this factor. This shouldn't be. The rough should be such that each golfer will make every effort to avoid it, to play the course as it is designed. For example, if a gradually tapered mound were placed in the landing zone of the rough, one which would stop the ball abruptly or send it bounding off line towards out-of-bounds stakes, the golfer would think twice before attempting to play into the rough. He would make every effort to shoot into the fairway as the hole was designed for play.

In preparation of roughs, trees should be cut back if necessary and all stumps removed. The latter may best be done by use of wood chipping machines that shave the stumps below the soil line. Then when covered with soil they decompose more quickly, but, more importantly, removal of stumps allows for immediate play over the area. If the stumps are relatively small, they may be pulled out with tractor and chain devices. In general, all undergrowth should be cleared. The architect, in

establishing the character of the course, may think that all except specimen trees should be removed from the rough. This may be from a distance of a few yards all the way to the club boundary lines.

Air Circulation

The clearing of underbrush is most important in creating a favorable environment for grass growth. Good air drainage is very important in summer; it helps avoid pockets of higher temperatures and humidity which weaken grass. Just so long as there is some air stirring over the turf, extraordinary problems will be avoided. It is important, then, to remove all underbrush that restricts air movement by using herbicide sprays or other means. If the wooded areas are so thick that it is impossible to do a complete removal job, then it is advisable at minimum to cut a path in the direction of the prevailing summer winds.

Root Pruning

Where trees are left standing because of strategic or aesthetic reasons, some root pruning may be required to minimize competition with turfgrass. This is done in two ways:

1. By using a root pruning device (commercially available) which attaches to a hydraulic lift on the tractor. This device slices into the soil with a minimum of turf disturbance and cuts off roots to a depth of 18 to 24 inches.

2. When troublesome roots are deeper than 24 inches, it is advisable to trench to the required depth and install galvanized sheeting and tar paper vertically (on end) to deter penetration in the future. The tar paper (heavy duty) is placed on the tree side of the trench.

If trees are planted, it is most desirable to place them in clusters rather than in straight lines. Most horticulturists advise planting trees in clusters of three, five, seven, or nine. Bear in mind the required spacing for maintenance, and the size of each tree when it matures. Trees placed so as to achieve vistas which emphasize key features of the course are most attractive and successful.

Soils in roughs, particularly in areas closely bordering fairways, must be prepared similarly to any other good seed bed for turfgrass growth. It is essential to remove all stones and debris and to work up the native soil to a depth of four inches. It is important to add limestone and nutrients (phosphorus in particular) and work them into the seed bed to the four-inch depth.

Grasses and seeding rates vary from region to region. In the northern areas, Kentucky bluegrasses and creeping red fescues are principally used. The creeping red fescues do best under minimum maintenance and so this turf usually results from a bluegrass-fescue seeding. If roughs are to be afforded good management, then the combination seeding is advised.

In southern golf courses the bermudagrasses are normally used.

In the transition zone, the tall fescue selections are coming more into prominent use. Because they form clumps when individual plants become established in fairways, seeding must be done carefully in order to confine this grass to the rough. Limestone and fertilizer should be added whenever soil tests and the density of the turf indicate a need.

The rough may be established when the golf course is built or it may evolve gradually over the years. The important things in construction are to provide for air circulation, particularly in the vicinity of putting greens; provide for efficient operation of maintenance equipment, and, above all, not to plant trees or shrubs that will upset the environment for important golf course features.

Bodies of Water

Streams and ponds can add greatly to the beauty and the player's enjoyment of a golf course. Water may be used in planning the strategy of play; large bodies of water can provide bonuses for fishing or boating. But unless bodies of water are handled properly, they can add tremendously to the maintenance effort.

Streams in rough areas may require little attention at the time of construction. Where they cross or border fairways, their possible effects upon future maintenance should be studied carefully. Stream banks should be stabilized if there is likelihood of erosion; wood or metal piling, stone or concrete are most frequently employed.

A major problem along streams is control of vegetation. Many banks are steep enough to prevent mowing with any type of power driven equipment, but the slopes do support weedy or brushy growth. In such cases the vegetation is useful in controlling erosion, and chemical eradication is not advisable.

The solution to the problem will depend upon the degree of slope. Sometimes the slope can be cut back and made gentle enough to permit mowing. Then turf can be established to stabilize the bank. If this is not possible, then the banks should be left fairly steep and stabilized by stone or pilings. Turf can then be mowed up to the top of the bank and unwanted vegetation in the channel can be removed by herbicides.

Where drains from fairways enter stream channels, the tile outlets should be embedded in concrete so that flood waters do not wash out sections of the tile drains. It is generally advisable to have the tile line approach the stream bank at a downstream angle.

Larger streams present a bridging problem. Golfers and golf carts must be provided a crossing. Bridges should be located out of the line of play if possible. The design and construction of bridges (even small ones) should not be done by amateurs. Competent engineering advice will permit construction of a bridge with adequate strength without unreasonable over design. The same rule applies to crossings for maintenance equipment.

Lakes and Ponds

Under some fortunate circumstances, a golf course is built on property where a natural lake exists. More often such a feature must be man-made.

Natural ponds may require relatively little work at the time of construction. Banks will usually be fairly well stabilized and serious leaks or seeps are unlikely to exist. Some attention may be necessary at the overflow point and it is likely that a concrete spillway structure to control the overflow will be needed. It may also be necessary to provide some alteration in the slope of banks for vegetation control.

Before construction of a lake or pond is started, the watershed area should be thoroughly investigated by competent individuals familiar with the practicability and the probable economic feasibility of the undertaking. They will be able to take advantage of the location of run-off of a given area, and this is where an aerial photo would be beneficial, as it permits plotting by visual inspection of the level and the hilly areas. If a photo is not available, the watershed boundary will have to be walked; in many cases this is preferable, as it permits better evaluation of the watershed run-off. If a topographical map of the drainage area is available, a planimeter can be used to determine the size of the watershed.

Vegetation growing in the watershed is very important as it has a significant effect upon pond sedimentation. It can influence usefulness of the pond with respect to aquatic life that may exist in it. Of course, those portions of the watershed not already protected against erosion will receive some

protection from the golf course after the grasses are established. If erosion is too severe, the pond may have to be constructed so that flood water will by-pass it and thereby reduce sediment in it. This is often done, and water is let into the pond only when silt or soil particles are not overly prevalent in the water.

Many bodies of water have been created before housing communities have been erected in the watershed, and the faster movement of the water from an area with substantial paving sometimes changes the entire nature of a pond. The spillway may have to be enlarged or a by-pass of the lake has to be re-designed to handle excess water that moves into the pond area.

There are several characteristics of a watershed that have direct bearing on the water yield and rate of water flow into the pond. They are the characteristics of the terrain, soil, infiltration, vegetative cover, and surface storage. These factors are very important and should be carefully observed during the preliminary investigation.

Sometimes the perviousness of soil is not taken into consideration, and a considerable amount of seepage and loss of water results. This may be corrected by the use of bentonite or other additives. Sheep foot rollers, like those used on highways, are sometimes used for compaction in the bottom of the lake. Seepage may be determined by digging holes 3 feet deep and pouring water in them to observe water movement. Depending on the size of the lake, impervious soil should be a minimum thickness of 24 inches. In many instances, the loss of water from evaporation is more serious than from leakage through the bottom of the lake. These relative losses depend upon climatic factors as well as the type of soil on which the lake is being located.

The foundation of the dam is highly important in lake construction. One needs to know conditions under the proposed dam site, and he needs to investigate carefully to insure a dam strong enough to prevent breakage during unusually heavy rainfall. In the event the dam should be located on rock, the rock should be carefully examined to see if there are any fissures or seams that will allow the water to pass through.

Suitable material for dam construction is very important and can be the determining factor in selection of the final site for the pond. In most cases, though, soil from the pond area itself will be used for the fill soil. It is preferable that the soil in the bank be of a homogenous nature to assure a better seal and a higher degree of stability.

According to the engineering handbook for work unit staffs for the U. S. Department of Agriculture, the best materials for embankments compacted under good moisture conditions contain a wide range of particle sizes, ranging from small gravel or coarse sand to fine sand and clay, with proportional amounts of each. Such soils should contain 10-20% by weight of clay particles. Soil materials that contain excessive amounts of clay will require that the side slopes of the embankment be relatively flat if they are to remain stable. Clay has a tendency to shrink when it is dry and it causes cracks to open. Quick rewetting may permit a free flow of water into the dam and could eventually result in breaking the dam. On the other hand, fill soils that have too high a percentage of coarse materials will allow the water to move through too rapidly, and they are therefore unsuitable.

After the dam site has been located and thoroughly studied, the spillway should be considered; and it is a rare occasion when one finds a natural spillway. It should be constructed so that it will accommodate flood flow within particular erosive velocity limitations, usually not exceeding 5.50 feet per second. This water should be discharged safely downstream from the toe of the dam and at a velocity which will not cause erosion. Where vegetation is not suitable for the spillway, then mechanical devices such as paved flumes or chutes, concrete drops or overfall, or drop inlet

spillways must be used. The original preliminary study will include studies of the topography that will influence the type of spillway that should be used.

Spillways have definite functions. They pass excessive run-off around or under the dam so water is not permitted to rise or go over the dam and cause a failure. The success and safety of the pond will depend on installation and design of the spillway or combination of spillways.

There are usually two classes of spillways, principal and emergency. In most cases dams and spillways are designed to control quantities of flood water based on a 25-year frequency of occurrence in a given area. The by-passing of the pond or lake with a side channel is very favorable in the event of a storm. Excess water does not move through the lake but by-passes it, and the only water running into the lake is that which overflows into or passes through the large pipes that run from the by-pass into the lake. It is advisable to engage a competent engineer or an agency that specializes in this sort of construction for a full detailed study of a particular situation.

Banks of ponds will require maintenance. If the pond is man-made, care in construction can render this problem less serious. In general, slopes of banks should be relatively steep. This provides less shallow water at the shore line where aquatic weeds are most troublesome. It also furnishes less exposed soil which will be agitated by wave action. Wave action is one of the causes of turbidity in water.

Some provision should be made to regulate spillway or overflow height. Changing the level of water in a pond periodically is one of the most effective methods of controlling marginal weeds. Water level control coupled with steep slopes can be very useful in reducing the maintenance on pond margins.

It is also well to provide during the construction period for complete drainage of the body of water. If seeps should develop, if nutria or muskrats should damage the retaining structures, or if rough fish should become over-abundant, an ability to drain the pond completely is most useful.

When ponds or creeks are used in the design of a golf hole, they often are most effective when placed very near to a tee or a green. Such design is pleasing and interesting, but care must be used to avoid a high water table in the green or tee area. This can interfere with subsurface drainage.

Ditches which serve as intermittent water courses

Among the most troublesome areas on the golf course from the standpoint of maintenance are ditches which normally are dry or carry only small amounts of continuous water flow but which become important water courses during storms. With proper treatment during golf course construction, these ditches can be rendered much less troublesome.

Concrete pipe to conduct any continuous flow across fairways may be buried in the bottom of the ditch. By creation of wide, gentle slopes, turf may be established throughout the ditch and the area may be mowed just like the rest of the fairway. The usefulness of the ditch in carrying storm water is not lessened by such treatment.

In out-of-play areas, these ditches or small streams should be graded to permit ready flow so that water is not trapped in small pockets.

Swamp Areas

Swamps or bogs occur on a surprising number of sites where construction of a golf course is proposed. These are so variable in nature and size that it is not possible to state any definite rules for their treatment.

If fairways are to be built through such areas, it is obviously necessary to drain and stabilize the area at the outset. It is folly to begin construction on swampy ground

before that portion which will accommodate the golf course proper has been drained and stabilized. Frequently, the job of drainage is more costly than the golf course construction.

Swamps in rough areas can be tolerated, but in general they are undesirable. Constantly wet areas may provide propagation grounds for mosquitoes, and they may be the source of unpleasant odors arising from decaying vegetation.

A general recommendation is that swamps or bogs be drained if the project is within range of economic feasibility.

Turf Nurseries

Stolon and sod turf nurseries are significantly important to the effective and economic operation of a golf course. Player demands are exacting, especially with regard to putting green surfaces. It is often difficult, if not impossible, to obtain top grade sod suitable for putting green use from an outside source. The more advanced and successful turf men maintain nursery turf for putting greens, be it to sod a new green or repair an older one. Sod nurseries for tees and fairways are of lesser importance. However, there is a general expansion in numbers of such nurseries, especially as interest in bentgrass and Merion bluegrass fairways increases.

Basically, there are two types of green nurseries in golf — stolon and sod. Stolon nurseries are prepared for two reasons:

1. A particular strain of vegetative grass is considered superior or continued perpetuation is desired. Generally, stoloniferous grass, especially bentgrass and bermudagrass, does not produce seed which perpetuates desired characteristics of the parent, or selected stoloniferous types fail to produce adequate seed. It is either not possible or practical to obtain seed from such grasses. Thus, the absolute necessity to perpetuate certain grasses through vegetation means.

2. It is known that a large supply of stolons will be required at a given time in the future for building or expansion. Stolon beds are established as some believe it less costly to grow stolons than to purchase them.

Stolon Bed Nursery

This discussion is specifically for bentgrass. However, the same will apply for other stoloniferous genera such as bermudagrass and Zoysia.

1. For figuring the size of stolon bed to prepare:

   a. One bushel of stolons will plant 1,000 linear feet of row.

   b. At the end of one growing season, 4.5 feet of row will produce 1 bushel of stolons. Therefore, at the end of one growing season, 1,000 linear feet of row (or the original bushel) will produce 222 bushels of stolons.

   c. Recommended stolonizing rates for producing sod are 8 to 10 bushels of stolons per 1,000 square feet. Therefore, 1 bushel of stolons at the end of one season of development will produce sufficient growth to stolonize approximately 20,000 square feet.

2. All nursery areas should be located in close proximity to the maintenance shop. This facilitates upkeep, as nurseries located in out-of-way areas are frequently neglected.

3. Water supply must be adequate.

4. Plow, level and thoroughly till area. Make every effort to choose a site with a suitable natural soil.

   a. Prior to final leveling, apply a complete fertilizer such as 10-10-10 or 12-12-12 at a rate of 30 pounds per 1,000 square feet. Be sure this heavy rate of fertilizer is mixed into the upper four inches of soil.

5. Soil sterilization is helpful. Steriliza-

tion is vital if different strains or types of the grass to be planted were previously present in the area. There are a number of ways to achieve soil sterilization and a variety of products are available. If the product used contains nitrogen, the fertilization rates suggested above should be adjusted accordingly. Methyl bromide gives the most complete sterilization of products currently used and has the advantage of celerity.

6. Plant stolons end to end, covering them slightly. Make rows four feet apart. At the end of one growing season, rows should be grown together.

7. Keep constantly moist until secondary growth has become well established.

8. Cultivate or hand pick foreign growth as necessary to keep area between rows clean.

9. Fertilize at least once a month. Use a natural organic product at a rate of 20 pounds per 1,000 square feet or a complete inorganic such as 10-5-5 or 12-6-6 at a rate of 10 pounds per 1,000 square feet.

10. The following spring or after one growing season, bentgrass will "shoot" seed heads. All seed heads must be destroyed. If destroying seed heads is considered too time-consuming or costly, the nursery should be destroyed and the entire process repeated. In any event, if seeds are allowed to develop and germinate in the stolon area, non-true strains of bentgrass will develop and the desired strain will be lost.

Sod Nursery: Putting Greens

As turf technology advances, it is increasingly obvious that a layer of foreign material or different type soil is detrimental to development and maintenance of satisfactory turf. Consequently, every effort should be taken to assure that the soil present on a sod putting green nursery site is identical to the soil present on the green site. If greens are constructed according to USGA Green Section specifications, a layer of 3 to 4 inches of the green topsoil mixture is to be placed over parent soil prior to stolonization.

1. Determine size of area desired. Reform area as necessary to assure adequate surface drainage. A 3% slope is adequate. Here again, the nursery should be located as near the maintenance building as possible.

2. Prepare soil in top 3 or 4 inches to conform with soil to be used in greens.

3. Mix into the upper soil mixture a complete inorganic product such as 10-10-10 or 12-12-12 at a rate of 30 pounds per 1,000 square feet.

4. Soil sterilization is recommended.

5. Level and smooth the entire area.

6. Stolonize at a rate of 8 to 10 bushels per 1,000 square feet.

7. Topdress, using material identical to that contained in the upper layer of soil or that immediately beneath the stolons. Topdressing rates are ⅓ to ½ cubic yard per 1,000 square feet.

8. Roll and firm.

9. Keep constantly moist until secondary growth has become well established.

10. After stolons have become established, topdress frequently and as heavily as practical in order to form a smooth, even surface. Uniformity of cut sod is dependent upon such a surface.

11. Specifically, maintain nursery following same practices as for greens (height of cut, fertilizer-fungicide-insecticide applications).

12. Whenever sod is removed, bring level of soil back to level of existing surrounding area and restolonize.

Sod Nursery: Tee

As in all nursery endeavors, tee nursery area should be located as close as possible to the maintenance shop. A tee nursery is most feasible or practical when top-class bentgrass, bermudagrass or Merion bluegrass teeing surfaces are demanded — at all times. A few years back, most authorities were hesitant to use stoloniferous bentgrass as a tee cover because of mat or "fluff" characteristics. However, traffic has increased to such an extent that this has

ceased to be a problem. Rather, the most vigorous stoloniferous types are being selected. Here again, a soil similar to that present on tees should be used for the nursery—thus dangerous layering is avoided following sodding.

Establish the size of nursery desired, and, in general, follow same maintenance practices as followed when maintaining tees.

A unique example of tee nurseries exists at Milwaukee Country Club. John Stampfl, who has been Superintendent there for many successful years, maintains a small bentgrass nursery adjacent to each tee. Sod or plugging material is immediately available.

Even though many Merion bluegrass nurseries have been established, many clubs which use this grass on tees find it economical and convenient to obtain sod from commercial sources.

Sod Nursery: Fairways

A few years back nursery sod for use on fairways was of no consideration. However, player demands are keeping pace with the increasing ability of the superintendent to maintain excellent turf. Many clubs have established and maintain fairway turf nurseries. Usually fairway sod nurseries are located adjacent to a fairway. The area is irrigated, cut, fertilized and, in general, receives the same treatment as the regular fairway turf if indeed it does not receive extra care through increased fertilization and disease control.

A factor involved in establishment of such turf nurseries is inability to obtain completely satisfactory bentgrass sod from commercial sources, especially when the sod is most urgently needed.

For general use or general repair purposes, sod is either borrowed from an out-of-play area or purchased.

It has been our observation that the most successful golf course superintendents are those who maintain adequate turf nurseries.

Trees for the Golf Course

"I think that I shall never see a poem lovely as a tree": so starts Joyce Kilmer's beautiful poem **Trees.** We have long recognized the economic importance and beauty of trees, and probably no other plant lends as much individual character to the landscape.

Richard Morgan Phelps in his master's thesis "The Influence of Planting in Golf Course Design" has said: "By carefully selecting and placing plant materials on any site, the designer may create moods; produce beautiful views and vistas; enclose spaces; enhance architecture and land formations; provide beauty, color, texture, fragrance, and scale; create illusion; provide privacy; and make man's environment more enjoyable in general."

There are 1,100 different species of trees native to the United States and many more important species which give an almost unlimited choice of size, shape and adaptability.

In an article in **Golfdom** Ralph B. Bryan stated: "It is recognized that the distinguishing mark of a superior golf course is the presence of good trees, wisely chosen and carefully tended. They are, almost invariably, genuine evidence that the course is designed and maintained for greatest pleasure."

Wise selection of trees for use in a particular area must be based on such considerations as topography, geology, ecology, climate, existing plant associations, type of golf course, individual characteristics of the species and the ideas club officials have of what they would like their course to be.

Topography can be accentuated or com-

plemented by judicious plantings, such as a picturesque specimen tree on gently rolling areas or bold groupings of plant materials on rugged sites. The height of hills may be greatly accentuated by planting tall growing trees on the crest and increasingly shorter trees toward the base, or the height may be negated by reversing the planting scheme.

The geology of the area should be studied and applied to tree selection. Obviously, a deep-rooted tree would not do well in an area with shallow soil underlaid with rock formations. Also, if the parent material is basically limestone, the soil may be alkaline, and pH adjustments should be made for acid-loving species or adapted species selected.

Ecological characteristics are important in choosing naturally adapted trees for the site. The ecology of an area determines native plant materials on the site, and new plantings should blend well with the native plants in most cases. A very new and different effect may sometimes be created by supplying new plantings with an element which is lacking, such as water in desert areas; however, as a rule, the most natural appearing and easily maintained landscaping is done with adapted or native varieties. Ecological considerations go hand in hand with climate and existing plant associations.

A good source of information concerning the adaptability of trees and plant materials is the U. S. Department of Agriculture Plant Hardiness Zone map or modification shown in Figure 1. Many authors list plants according to this map and most land grant colleges and universities, county agents or reputable landscape designers can provide additional information as to adaptability of species in a given area.

Type of golf facility is a major consideration in selecting suitable trees. The par-3 course is a relatively new idea in golf facilities and requires different concepts in design of plantings. On this type of facility, smaller trees and some shrubs are useful as they are more to scale. The larger trees may be used as screens, hazards, directional guides or for protection. Trees for par-3 courses suggested by Phelps are hawthorns **Crataegus spp.),** Amur maple **(Acer ginnals),** shadblow serviceberry **(Amelanchier canadensis),** Eastern redbud **(Cercis canadensis),** and many of the crabapples **(Malus spp.)**

Regulation courses may be divided into four general types when selecting trees: private, public or municipal, rural, and urban. The private, rural country club offers the most possibilities in selecting trees. Private clubs usually have more funds available for beautification of the course and as a rule have a limited number of golfers. Being in the country avoids city smoke and fumes which are sometimes toxic to some trees.

On the other hand, municipal courses tend to draw capacity play, and partly because of economic considerations and partly because of the type of golfer, emphasis is placed on sparse, open plantings for easier maintenance, faster play and smaller initial expenditure.

Once you have decided which trees are best suited to your area and your type of golf course, then the individual characteristics of each tree come into play in deciding on the specific location on the course. Careful consideration is given this subject in the following excerpt from Mr. Phelps' thesis work:

Greens

Trees that are to be placed near putting surfaces should possess characteristics that will allow turfgrass on the green to grow without interference. These characteristics include deep rooting, light or filtered shade, absence of litter, small volumes of leaves, strong branching, lack of insects and diseases, and unobtrusive coloration. Unfortunately no tree possesses all these characteristics.

As a result, trees with several of these characteristics are recommended. It must be emphasized that trees of many types are appropriate around greens, depending on

their placement. Trees that are deep-rooting, strong, long-lived, and litter-free may cast dense shade or possess volumes of leaves. If these trees are placed so that their shadows are not cast upon the putting surface, they would be considered acceptable. Modern mulching equipment is able to handle the leaf problem easily. Many trees not mentioned in the following list may be used near greens, but they must be used with great care. The oaks (Quercus spp.) are of this type.

In general, shrubs are not recommended in the vicinity of greens. In special cases, they may be useful as protection for nearby tees, or to help prevent a ball from going out-of-bounds. Some golf course architects might consider them desirable as obstacles.

Trees may be of any height; however, high-branching varieties are preferred. The outer foliage line of the tree at maturity should be not closer than 15 feet from the edge of the green. Trees to be placed far behind the green will be considered under the listing "backgrounds".

Tees

Plant materials to be used in the vicinity of tees may possess characteristics that differ from those placed around greens. Trees may be lower branching, possess larger volumes of leaves, and be more colorful. Shrubs are often valuable around tees as a means of providing color and fragrance. Care must be taken, however, to insure adequate air circulation, sunlight, and branching height for the tee area. Deep-rooting trees should be specified to eliminate root problems. Many shallow-rooting trees may be used if the tee area is properly watered to encourage deeper rooting by the tree.

Trees placed near the tee should be placed closer to the edges at the rear of the tee and farther from the sides in front to allow ample clearance for a golf shot made from the rear. For the same reason, overhanging trees should not be used near the front of long tees.

Sunlight must reach all parts of the tee during a majority of the day to insure healthy turf. Trees and tall shrubs are valuable as shade providers if they are placed with care. Benches for resting may be placed in this shade while still allowing close proximity to the tee and full vision of the tee and fairway.

Fairways

Plant materials suited for fairways differ slightly from those used near greens and tees. Fairway turf requires adequate amounts of light and nutrients. As a result, trees should be rather open and deep-rooted; shallow-rooted trees rob grasses of water and nutrients. Shrubs should not be used on fairways. Litter should be kept to a minimum, although leaves and small twigs are not as objectionable in fairways as they are on greens. They may be easily mulched or removed by hoses, spray equipment, or rakes. Trees should be high-branching to avoid interference with a player's swing. Trees may possess interesting color such as flowers, foliage, fruit, or bark. They may also be picturesque or symmetrical in shape.

Trees placed on fairways should be used sparingly and set in strategic locations. Placement of any trees in a fairway should be thoroughly and thoughtfully considered before they are specified. They have a definite place in the design of golf courses, but they must not be over-used.

Roughs

Trees and shrubs to be used in the rough may be of nearly any variety. Much will depend upon the type of golf facility, existing plant materials, and attitudes of local golfers. In general, municipal courses should use trees similar to those recommended for use on fairways. In addition, shrubs for use in the roughs should be avoided. Privately-owned courses open to the public where play is not as heavy may specify either, or a combination of the two.

Plant materials in the roughs may be valued for their color, shape, bark, texture, specimen or massing use, and qualities as

an obstacle. They should allow medium to high amounts of light to filter through to the turf and should be at least moderately free of insects and diseases, litter, and root problems. Some plant materials to be used out of the normal range of play will be mentioned under the subject: "Plants for Wildlife Areas." Other plants to be used in remote areas of the course should be native to the area or should provide material for specific uses such as lumber, specimens for arboretums, or nursery stock.

Table 1
Plant Materials Recommended for Greens, Tees, Fairways, and Roughs

Scientific name	Common name	Use*
Acer nigrum	Black Maple	R
Acer rubrum	Red Maple	R
Acer saccharum	Sugar Maple	R
Albizzia julibrissin	Silktree Albizzia	G,T,F,R
Alnus spp.	Alders	R
Amelanchier spp.	Serviceberries	R
Betula lenta	Sweet Birch	R
Betula lutea	Yellow Birch	F,R
Betula nigra	River Birch	G,T,F,R
Betula papyrifera	Paper Birch	G,T,F,R
Betula populifolia	Gray Birch	G,T,F,R
Catalpa speciosa	Northern Catalpa	R
Celtis laevigata	Sugar Hackberry	F,R
Celtis occidentalis	Common Hackberry	F,R
Cercidiphyllum japonicum	Katsuratree	F,R
Cercis canadensis	Eastern Redbud	T,R
Chionanthus virginicus	White Fringetree	T,R
Cladrastis lutea	American Yellowwood	R
Crataegus spp.	Hawthorns	T,R
Diospyrus virginiana	Common Persimmon	R
Elaeagnus angustifolia	Russianolive	R
Fraxinus spp.	Ash	F,R
Ginkgo biloba	Ginkgo	G,T,F,R
Gleditsia triacanthos inermis	Thornless, seedless Honeylocust	G,T,F,R
Gymnocladus dioicus	Kentucky Coffeetree	R
Halesia carolina	Carolina Silverbell	R
Kalopanax pictus	Castor Aralia	T,F,R
Koelreuteria paniculata	Panicled Goldenrain-Tree	G,T,F,R
Lagerstroemia indica	Common Crapemyrtle	R
Larix decidua	European Larch	G,T,F,R
Larix laricina	Eastern Larch	G,T,F,R
Liquidamber styraciflua	American Sweetgum	R
Liriodendron tulipifera	Tuliptree	F,R
Malus spp.	Crabapples	R
Nyssa sylvatica	Black Tupelo	G,T,F,R
Ostrya virginiana	American Hornbeam	T,R
Oxydendrum arboreum	Sourwood	R
Paulownia tomentosa	Royal Paulownia	R
Phellodendron amurense	Amur Corktree	F,R
Phellodendron lavallei	Lavalle Corktree	F,R
Pinus banksiana	Jack Pine	G,T,F,R
Pinus flexilis	Limber Pine	R
Pinus nigra	Austrian Pine	F,R
Pinus palustris	Longleaf Pine	G,T,F,R
Pinus ponderosa	Ponderosa Pine	R
Pinus resinosa	Red Pine	R
Pinus rigida	Pitch Pine	T,F,R
Pinus strobus	White Pine	R
Pinus sylvestris	Scotch Pine	T,F,R
Pinus taeda	Loblolly Pine	T,F,R
Platanus acerifolia	London Planetree	F,R
Platanus occidentalis	American Planetree	F,R
Quercus borealis	Northern Red Oak	F,R
Quercus coccinea	Scarlet Oak	F,R
Quercus palustris	Pin Oak	F,R
Quercus velutina	Black Oak	F,R
Quercus spp.	Oak	R
Robinia pseudocacia	Black Locust	F,R
Sassafras albidum	Common Sassafras	R
Sophora japonica	Japanese Pagodatree	T,F,R
Sorbus spp.	Mountainash	R
Syringa amurensis	Amur Lilac	R
Syringa amurensis japonica	Japanese Tree Lilac	R
Ulmus americana	American Elm	T,F,R
Ulmus carpinifolia var.	Christine Buisman Elm	T,F,R
Ulmus glabra	Scotch Elm	T,F,R
Zelcova serrata	Japanese Zelcova	F,R

*Green—G Tee—T Fairway—F Rough—R

Specimens

Almost any plant may be valued as a specimen in planting designs. However, trees and shrubs considered as desirable specimens usually possess an outstanding characteristic, such as beautiful flowers, seasonal color, special form, or special texture. Use of too many specimen plants tends to defeat their purpose and results in a mass of oddities instead of a unified composition of clumps and groupings. Occasional single specimens or small specimen clumps are desirable. The current trend of making every tree or shrub on the golf course a specimen is illogical, regardless of mowing considerations. Some degree of esthetic feeling must be left on our modern courses.

Table 2
Trees Suited for Use as Specimens

Scientific name	Common name
Abies spp.	Fir
Acer nigrum	Black Maple
Acer palmatum	Japanese Maple
Acer saccharum	Sugar Maple
Acer tataricum	Tatarian Maple
Aesculus spp.	Buckeye; Horsechestnut
Amelanchier spp.	Serviceberry
Betula spp.	Birch
Carya illinoensis	Pecan
Carya ovata	Shagbark Hickory
Cedrus spp.	Cedar
Cercidiphyllum japonicum	Katsuratree
Cercis canadensis	Eastern Redbud
Chamaecyparis spp.	Falsecypress
Chionanthus virginicus	White Fringtree
Cladrastis lutea	American Yellowwood
Cornus florida	Florida Dogwood
Cornus kousa	Kousa Dogwood
Crataegus spp.	Hawthorn
Fagus spp.	Beech
Ginkgo biloba	Ginkgo
Gymnocladus dioicus	Kentucky Coffeetree
Hamamelis virginiana	Common Witchhazel
Juniperus chinensis	Pyramid Chinese Juniper
Koelreuteria paniculata	Panicled Goldenrain-Tree
Larix spp.	Larch
Liquidamber styraciflua	American Sweetgum
Liriodendron tulipifera	Tuliptree
Magnolia spp.	Magnolia
Malus spp.	Apple; Crabapple
Nyssa sylvatica	Black Tupelo

Ostrya virginiana	American Hophornbeam
Oxydendrum arboreum	Sourwood
Phellodendron amurense	Amur Corktree
Phellodendron lavallei	Lavalle Corktree
Picea spp.	Spruce
Pinus spp.	Pine
Prunus spp.	Apricot; Cherry; Chokecherry; Laurelcherry; Peach; Plum
Quercus spp.	Oak
Salix spp.	Willow
Sciadopitys verticillata	Umbrellapine
Sophora japonica	Japanese Pagodatree
Syringa amurensis japonica	Japanese Tree Lilac
Taxodium spp.	Baldcypress
Taxus cuspidata commutata	Japanese Yew
Thuja spp.	Arborvitae
Tilia spp.	Linden
Toona sinensis	Chinese Toona
Tsuga spp.	Hemlock
Ulmus americana	American Elm

Table 3

Shrubs Suited for Use as Specimens

Scientific name	Common name
Caragana arborescens	Siberian Peashrub
Chaenomeles spp.	Floweringquince
Cotinus coggygria	American Smoketree
Euonymus alatus	Winged Euonymus
Euonymus americanus	Brook Euonymus
Euonymus atropurpureus	Eastern Wahoo
Euonymus europaeus	European Euonymus
Exochorda spp.	Pearlbush
Halesia spp.	Silverbell
Hibiscus spp.	Hibiscus, Rosemallow
Hydrangea spp.	Hydrangea
Lonicera spp.	Honeysuckle
Prunus japonica	Chinese Bushcherry
Prunus triloba	Flowering Plum
Rhododendron spp.	Rhododendron; Acalea
Rhus spp.	Sumac
Viburnum spp.	Viburnum

Background

Many trees and shrubs possess characteristics that are valuable for background purposes. Plants of this type are often used behind greens, as a terminus of a view, for direction indicators, and as backgrounds for flowering specimens.

Trees and shrubs should be dense and heavy in appearance. Usually, their color is dark and ranges from dark green to purple-green or blue-green. Often they branch to the ground; however, this is not a steadfast requirement. Background plant materials may also possess color, texture, form, or fragrance characteristics of their own.

Table 4

Plant Materials for Background

Scientific name	Common name
Abies spp.	Fir
Acer spp.	Maple
Aesculus spp.	Buckeye; Horsechestnut
Alnus spp.	Alder
Cedrus spp.	Cedar
Chamaecyparis spp.	Falsecypress
Cornus florida	Flowering Dogwood
Crataegus spp.	Hawthorn
Diospyros virginiana	Common Persimmon
Fagus spp.	Beech
Ginkgo Biloba	Ginkgo
Hamamelis virginiana	Common Witchhazel
Ilex spp.	Holly
Juniperus spp.	Juniper
Liquidamber styraciflua	American Sweetgum
Nyssa sylvatica	Black Tupelo
Paulownia tomentosa	Royal Paulownia
Phellodendron spp.	Corktree
Picea spp.	Spruce
Pinus spp.	Pine
Pseudotsuga spp.	Douglasfir
Quercus spp.	Oak
Rhamnus spp.	Buckhorn
Rhus spp.	Sumac
Sophora japonica	Japanese Pagodatree
Staphylea trifolia	American Bladdernut
Syringa spp.	Lilac
Taxus spp.	Yew
Thuja occidentalis	Eastern Arborvitae
Tilia spp.	Linden
Viburnum spp.	Virburnum

Plants for wildlife areas

Certain plant materials possess characteristics that are more favorable for wildlife. These plants may provide nesting areas, protection and food for many kinds of birds and animals. Many of our common plant materials provide seeds or fruits that wildlife require for survival, and these materials can easily be included in most plantings for golf courses.

Table 5

Plant Materials Valuable to Wildlife

Scientific name	Common name
Amelanchier spp.	Serviceberry
Aronia spp.	Chokeberry
Berberis spp.	Barberry
Betula lenta	Sweet Birch
Betula lutea	Yellow Birch
Betula nigra	River Birch
Betula populifolia	Gray Birch
Carya spp.	Hickory
Celastrus spp.	Bittersweet
Celtis spp.	Hackberry
Chionanthus spp.	Fringetree
Cornus spp.	Dogwood
Corylus americana	American Filbert
Cotoneaster spp.	Cotoneaster
Crataegus spp.	Hawthorn
Elaeagnus angustifolia	Russianolive
Euonymus spp.	Euonymus
Gaultheria procumbens	Checkerberry Wintergreen
Hippophae rhamnoides	Common Seabuckthorn
Ilex opaca	American Holly
Ilex verticillata	Common Winterberry
Juglans spp.	Walnut
Juniperus spp.	Juniper
Larix spp.	Larch
Lespedeza spp.	Lespedeza
Ligustrum spp.	Privet
Lindera spp.	Spicebush
Lonicera spp.	Honeysuckle
Malus spp.	Apple, Crabapple
Morus spp.	Mulberry
Myrica spp.	Bayberry; Waxmyrtle
Nyssa spp.	Tupelo
Parthenocissus spp.	Creeper

Picea spp.	Spruce
Pinus spp.	Pine
Prunus spp.	Apricot; Cherry; Chokecherry; Laurelcherry; Peach; Plum
Pyracantha spp.	Firethorn
Quercus spp.	Oak
Rhamnus spp.	Buckthorn
Rhus spp.	Sumac
Ribes spp.	Currant; Gooseberry
Rubus spp.	Blackberry; Dewberry; Raspberry
Sambucus spp.	Elder
Shepherdia spp.	Buffaloberry
Sorbus spp.	Mountainash
Symphoricarpos spp.	Snowberry
Tamarix gallica	French Tamarisk
Tsuga spp.	Hemlock
Vaccinium spp.	Blueberry
Viburnum spp.	Viburnum
Vitis spp.	Grape

Screens and windbreaks

Plant materials that are suitable for windbreaks or screens should possess several important characteristics. They must be dense and low branching. They may be fast or moderate in growth. They may have thorns in instances where they are needed as boundary screens or barriers. They must be able to withstand effects of wind and exposure. They may or may not be evergreen, depending upon their specific use. Evergreens are useful throughout the year, while deciduous materials are useful as windbreaks only during a portion of the year.

Table 6
Plant Materials for Screens and Windbreaks

Scientific name	Common name
Acer campestre	Hedge Maple
Acer ginnala	Amur Maple
Acer negundo	Boxelder
Acer saccharinum	Silver Maple
Acer tataricum	Tatarian Maple
Ailanthus altissima	Treeofheaven Ailanthus
Berberis spp.	Barberry
Caragana spp.	Peashrub
Carpinus spp.	Hornbeam
Catalpa spp.	Catalpa
Chaenomeles japonica	Floweringquince
Cornus spp.	Dogwood
Cotoneaster spp.	Cotoneaster
Crataegus spp.	Hawthorn
Euonymus alatus	Winged Euonymus
Fagus spp.	Beech
Gleditsia triacanthos	Common Honeylocust
Hamamelis virginiana	Common Witchhazel
Hippophae rhamnoides	Common Seabuckthorn
Juniperus spp.	Juniper
Larix spp.	Larch
Ligustrum spp.	Privet
Lonicera spp.	Honeysuckle
Maclura pomifera	Osageorange
Mahonia aquifolium	Oregongrape
Morus spp.	Mulberry
Phellodendron amurense	Amur Corktree
Philadelphus spp.	Mockorange
Physocarpos opulifolius	Common nineback
Picea spp.	Spruce
Pinus banksiana	Jack Pine
Pinus ponderosa	Ponderosa Pine
Pinus resinosa	Red Pine
Pinus strobus	Eastern White Pine
Pinus sylvestris	Scotch Pine
Platanus orientalis	American Planetree
Populus spp.	Poplar
Prunus spinosa	Sloe; Blackthorn
Ptelea trifoliata	Common Hoptree
Pyracantha spp.	Firethorn
Rhamnus spp.	Buckthorn
Robinia pseudoacacia	Black Locust
Rosa spp.	Rose
Salix spp.	Willow
Sambucus canadensis	American Elder
Staphylea trifolia	American Bladdernut
Thuja spp.	Arborvitae
Tsuga spp.	Hemlock
Viburnum spp.	Viburnum

Undesirable Characteristics of Plants

Many unsuitable plant materials are used on golf courses. Such plants add greatly to the yearly cost of maintenance. Most plants possess undesirable characteristics, such as litter, odor,, soft wood, troublesome roots, quantities of leaves, or insect and disease. However, some are recommended when their desirable characteristics dominate their undesirable characteristics.

The following lists of plant materials should be regarded as indicators, since all plant materials have not been listed. Of the plants that are listed, many considered to be undesirable in one section of the country may be desirable in another. For example, Siberian elm **(Ulmus pumila)**, boxelder **(Acer negundo)**, Russianolive **(Elaeagnus angustifolia)**, poplars **(Populus spp.)**, and willows **(Salix spp.)** may be undesirable in the Northeast (region 1), while serving very well in the Northern plains (region 4).

Table 7
Undesirable Materials Due to Litter

Scientific name	Common name	Problem
Acer negundo	Boxelder	storm damage
Acer rubrum	Red Maple	storm damage
Acer saccharinum	Silver Maple	brittle, storm damage
Aesculus spp.	Buckeye; Horsechestnut	storm damage twigs, fruit
Ailanthus altissima	Treeofheaven Ailanthus	fruit, storm damage
Betula papyrifera	Paper Birch	storm damage
Carya spp.	Hickory	fruit
Castanea dentata	American Chestnut	fruit
Catalpa spp.	Catalpa	fruit
Cedrus spp.	Cedar	fruit (cones)
Citrus genera	Citrus	fruit
Cladrastis lutea	American Yellowwood	storm damage

Diospyros virginiana	Common Persimmon	storm damage
Fagus spp.	Beech	fruit
Fraxinus spp.	Ash	fruit, storm damage
Ginkgo biloba (female)	Ginkgo	fruit
Gleditsia triacanthos	Common Honeylocust	fruit pod
Gymnocladus dioicus	Kentucky Coffeetree	fruit pod, storm damage
Juglans spp.	Walnut	fruit
Koelreuteria paniculata	Panicled Goldenrain-Tree	storm damage
Liquidamber styraciflua	American Sweetgum	fruit
Liriodendron tulipifera	Tuliptree	storm damage
Maclura pomifera	Osageorange	fruit
Malus spp.	Apple; Crabapple	fruit
Morus spp.	Mulberry	weed tree, fruit
Picea spp.	Spruce	cones
Pinus spp.	Pine	cones
Platanus spp.	Planetree	storm damage, fruit
Populus spp.	Poplar	storm damage, seeds, twigs
Prunus spp.	Apricot; Cherry; Chokecherry; Laurelcherry; Peach; Plum	fruit
Pyrus spp.	Pear	fruit
Quercus spp.	Oak	fruit
Robinia pseudoacacia	Black Locust	storm damage, fruit pods
Salix spp.	Willow	storm damage, twigs, seeds
Sambucus spp.	Elder	storm damage
Schinus molle	California Peppertree	fruit
Sorbus spp.	Mountainash	fruit
Tilia americana	American Linden	storm damage
Ulmus spp.	Elm	fruit, twigs storm damage

Table 8
Undesirable Materials due to Dense Shade

Scientific name	Common name
Abies spp.	Fir
Acer ginnala	Amur Maple
Acer macrophyllum	Bigleaf Maple
Acer nigrum	Black Maple
Acer platanoides	Japanese Maple
Acer saccharum	Sugar Maple
Acer tataricum	Tatarian Maple
Aesculus hippocastanum	Common Horsechestnut
Asimina triloba	Common Pawpaw
Catalpa speciosa	Northern Catalpa
Cornus florida	Flowering Dogwood
Cornus mas	Corneliancherry Dogwood
Euonymus alatus	Winged Euonymus
Euonymus atropurpureus	Eastern Wahoo
Fagus spp.	Beech
Ilex spp.	Holly
Juniperus spp.	Juniper
Kalmia latifolia	Mountainlaurel Kalmia
Ligustrum spp.	Privet
Magnolia spp.	Magnolia
Morus spp.	Mulberry
Paulownia tomentosa	Royal Paulownia
Picea spp.	Spruce
Pseudotsuga spp.	Douglasfir
Quercus alba	White Oak
Quercus bicolor	Swamp White Oak
Quercus borealis	Northern Red Oak
Quercus macrocarpa	Bur Oak
Quercus robur	English Oak
Rhododendron spp.	Rhododendron, Azalea
Taxus spp.	Yew
Thuja spp.	Arborvitae
Tilia spp.	Linden
Tsuga spp.	Hemlock
Viburnum spp.	Viburnum

Table 9
Undesirable Materials due to Roots

Scientific name	Common name	Problem
Acer negundo	Boxelder	suckers
Acer platanoides	Norway Maple	surface
Aesculus parvifolia	Bottlebrush Buckeye	suckers
Ailanthus altissima	Treeofheaven Ailanthus	suckers
Alnus spp.	Alder	suckers
Amelanchier spp.	Serviceberry	surface
Asimina triloba	Common Pawpaw	surface
Carpinus spp.	Hornbeam	surface
Cercidiphyllum japonisum	Katsuratree	surface
Cladrastis lutea	American Yellowwood	surface
Cornus alba sibirica	Siberian Dogwood	suckers
Cornum amomum	Silky Dogwood	suckers
Cornum stolonifera	Redosier Dogwood	suckers
Fagus spp.	Beech	surface
Fraxinus spp.	Ash	surface
Hydrangea spp.	Hydrangea	suckers
Liriodendron tulipifera	Tuliptree	suckers
Maclura pomifera	Osageorange	surface
Morus alba	White Mulberry	surface
Morus rubra	Red Mulberry	surface
Ostrya virginiana	American Hophorn beam	surface
Phellodendron amurense	Amur Corktree	surface
Populus spp.	Poplar	surface
Prunus americana	American Plum	suckers
Prunus pennsylvanica	Pin Cherry	suckers
Prunus virginiana	Common Chokecherry	suckers
Rhus spp.	Sumac	suckers
Robinia pseudoacacia	Black Locust	shallow-suckers
Salix spp.	Willow	shallow-suckers
Sambucus canadensis	American Elder	suckers
Sorbus spp.	Mountainash	shallow-suckers
Staphylea trifolia	American Bladdernut	suckers
Syringa vulgaris	Common Lilac	suckers
Tsuga spp.	Hemlock	surface
Ulmus spp.	Elm	surface
Viburnum spp.	Viburnum	suckers
Zanthoxylum spp.	Pricklyash	suckers
Zelcova serrata	Japanese Zelcova	surface

Table 10
Undesirable Materials due to Susceptibility to Diseases and Insects

Scientific name	Common name
Abies balsamea	Balsam Fir
Acer negundo	Boxelder
Acer saccharinum	Silver Maple
Aesculus hippocastanum	Common Horsechestnut
Alnus japonica	Japanese Alder
Amelanchier spp.	Serviceberrry
Betula spp.	Birch
Carya spp.	Hickory
Castanea spp.	Chestnut
Celtis spp.	Hackberry
Cornus alternifolia	Pagoda Dogwood
Crataegus spp.	Hawthorn
Cydonia oblonga	Common Quince
Euonymus spp.	Euonymus
Fraxinus spp.	Ash
Gleditsia japonica	Japanese Honeylocust
Halesia carolina	Carolina Silverbell
Ilex aquafolium	English Holly
Ilex opaca	American Holly
Juglans spp.	Walnut
Juniperus spp.	Juniper
Larix spp.	Larch
Malus spp.	Apple; Crabapple

Photinia spp.	Photinia	Rhamnus spp.	Suckthorn
Platanus occidentalis	American Planetree	Rhus spp.	Sumac
Populus spp.	Poplar	Robinia spp.	Locust
Prunus spp.	Apricot; Cherry; Laurelcherry; Peach, Plum	Salix spp.	Willow
		Sorbus spp.	Mountainash
Ptelea trifoliata	Common Hoptree	Syringa spp.	Lilac
Pyrus spp.	Pear	Tilia spp.	Linden
Quercus borealis	Northern Red Oak	Ulmus spp.	Elm

Trees Suitable For Western U. S.

The foregoing tables are probably the most comprehensive published to date dealing specifically with trees suitable for the golf course. Even though Mr. Phelps' lists are quite extensive, you may judge from the following lists of trees suitable for planting on desert, inland, and coastal golf courses in the far west the importance of seeking local advice before making selections. The three lists, prepared by Chauncy I. Jerabek, for the San Diego Park and Recreation Department, San Diego, Calif., include a wide variety of palm trees suitable for desert areas which are omitted from Mr. Phelps' lists and include such species as cedar and arborvitae, listed by Mr. Phelps as undesirable. The difference is most likely attributed to limitations in the number of adapted species for these specific western areas and the undesirable characteristics are overshadowed by a need for varied plant materials.

by Chauncy I. Jerabek

COASTAL AREAS

Scientific Name	Common Name
1. Angophora lancelata	Gum myrtle
2. Acacia baileyana	Cootamunda Wattle
3. Acacia dealbata	Silver Wattle
4. Acacia pendula	Weeping Myall
5. Cordyline australis	Green Dracena
6. Callistemon uiminalis	Weeping Bottle Tree
7. Melaleuca genistifolia	Snowy Fleece Tree
8. Melaleuca huegelii	Chenille Honey Myrtle
9. Agonis flexousa	Willow Myrtle
10. Ceratonia siliqua	Carob
11. Metrosideros tomentosa	New Zealand Christmas Tree
12. Lingustrum japonicum var. macrophyllum	Broad leaf Privet
13. Fraxinus uhdei	Evergreen
14. Harpephyllum caffrum	Kafir Plum
15. Podocarpus gracilior	Yellow Wood
16. Trachycarpus excelsus	Windmill Palm
17. Howea forsteriana	Thatch leaf Palm
18. Archontophoenix cunninghamiana	Seaforthia elegans
19. Eucalyptus globulus compacta	Compact Blue Gum
20. Eucalyptus ficifolia	Scarlet flowering Gum
21. Eucalyptus polyanthemos	Red Box
22. Eucalyptus sideroxylon rosea	Pink flowering Iron Bark
23. Pinus canariensis	Canary Island Pine
24. Pinus pinea	Umbrella Pine
25. Pinus torreyana	Torrey Pine
26. Sequoia sempervirens	Coast Redwood
27. Pinus hallipensis	Aleppo Pine

DESERT AREAS

Scientific Name	Common Name
1. Cordyline australis	Green Dracena
2. Dracaena draco	Dragon Palm
3. Erythea edulis	Guadalupe Palm
4. Erythea elegans	Mexican Blue Palm
5. Erythea armata	Sabal Palm
6. Sabal palmetto	California Fan Palm
7. Washington filifera	India Date Palm
8. Phoenix sylvestris	Wine Palm
9. Jubaea spectabilis	Pindo or Jelly Palm
10. Butia australis	Windmill Palm
11. Trachycarpus fortunei	Giant Bird of Paradise
12. Strelitizia nicolai	California Pepper Tree
13. Schinus molle	Common Olive
14. Olea europaea	Bottle Tree
15. Brachychiton populneum	Carob
16. Ceratonia siliqua	Snowy Fleece Tree
17. Melaleuca genistifolia	Cajeput Tree
18. Melaleuca leucadendra	Bottle Tree
19. Callistemon citrinus	Willow Myrtle
20. Agonis flexuosa	Sea Urchin
21. Hakea laurina	Bottle Tree
22. Callistemon lanceolatus	Jerusalem Thorn
23. Parkinsonia aculeata	Carrot Wock
24. Cupania anacardioides	Cork Oak
25. Quercus suber	

INLAND AREAS

Scientific Name	Common Name
1. Pinus canariensis	Canary Island Pine
2. Pinus muricata	Bishop or Prickle Pine
3. Pinus radicata	Monterey Pine
4. Pinus sabinana	Digger Pine
5. Pinus sylvestris rigensis	Scotch Pine
6. Cedrus deodara	Deodara Cedar, Indian Cedar
7. Cedrus atlantica	Atlas Cedar
8. Cedrus libani	Cedar of Lebanon
9. Libocedrus decurrens	Incense Cedar
10. Thuja occidentalis pyramidalis	American Arborvitae
11. Thuja plicata	Giant Arborvitae
12. Taxus bacata	English Yew
13. Torreya californica	California Nutmeg
14. Acacia baileyana	Cootamunda Wattle
15. Schinus mlle	California Pepper
16. Brachychiton populneum	Bottle Tree

17. Ceratonia siliqua	Carob
18. Umbellularia californica	California Laurel
19. Washingtonia filifera	California Fan Palm
20. Eucalyptus polyanthemos	Red Box
21. Eucalyptus sideroxylon rosea	Pink Iron Bark
22. Eucalyptus rostrata	Red Gum
23. Olea Europaea	Common Olive
24. Ilex opaca	American Holly
25. Ilex aquifolium	English Holly
26. Pinus	Italian Stone Pine

After the proper species have been selected, there comes the task of placing trees with proper spacing and alignment. By all means, the planting should look natural and in many cases may be functional. Consideration should be given to the type of equipment which will maintain the area around the trees. All too often trees are planted too close together or too close to other objects, necessitating time-consuming hand work to trim up the area. It is easy to see the folly of planting trees 10 feet apart when the mower used to maintain the area is 14 feet wide.

Straight row planting should also be avoided where possible. This type of planting is not only unimaginative but unnatural and basically unattractive; the trees look more like a row of fence posts and give the appearance of artificial props.

In the final analysis, the ideas that club members and officials have of what type of course they want come into play. We have already mentioned the fact that fewer trees speed up play and make for easier maintenance; however, these considerations are secondary to aesthetic surroundings and enjoyment or strategy of the game at many clubs.

A golfer from the plains of Kansas may have one idea of how a golf course should look and a man from Colorado another idea. One is accustomed to a course densely populated with trees, while the other is accustomed to the wide-open spaces; however, both may have a well-designed and attractive course. Though the man from Kansas may have only a few trees on his course on the plains, he could hardly deny the aesthetic importance of these few specimen trees or their usefulness to the golfer and the game.

Club members and officials should keep the future in mind. Trees take years to develop and care along the way. Tree nurseries are helpful and long-range planting plans are essential to establish new trees as old trees fade away and to place new trees where none existed before so that they may be enjoyed by future generations. Trees planted now are monuments of our concern and thoughtfulness for tomorrow.

Irrigation

The irrigation system will be one of the most costly parts of a new golf course. Its planning should be given a great deal of attention.

Some golf architects have irrigation engineering capabilities and may be able to provide the necessary plans. More often this planning phase of the work is left to the organization which will supply the equipment, and the installation is the function of a subcontractor who submits a low bid.

The principles of irrigation are quite simple, but variabilities which impose themselves make irrigation practice rather complex. The purpose of the irrigation system is to provide sufficient water to make up the deficit between rainfall and the amount of water consumed by the plants, lost through runoff, and evaporated into the atmosphere.

There have been many attempts to calculate the amounts of water necessary to compensate for these losses and to provide adequate moisture for turf. Some of the calculations are quite useful. The fact re-

mains however, that variabilities in rainfall, in terms of amounts, rate of precipitation, and distribution, combine to make it impossible to cite absolute quantities.

There are good books on irrigation which describe the needs of turf, the variables to be considered, and the advantages and disadvantages of various types of systems. Such texts are well worth studying if one is planning to install a system. Such reading will provide some background upon which one can base a discussion with his designer or contractor. It should be borne in mind, however, that all the printed information extant will not take the place of practical experience. Design of an irrigation system is no job for an amateur.

It is important, then, to have a competent engineer to design an irrigation system and to supervise its installation.

Because of the fact that irrigation systems are expensive, it is tempting to shop around for a system "just as good" but cheaper. Shopping around is good business, but if you find out a given system is considerably cheaper than others, you should also find out why it is cheaper.

Greater spaces between sprinklers is very effective as a cost-reducing practice, but if wind distorts sprinkler patterns, dry spots may occur. Smaller pipe sizes lead to cheaper installation, but the price is increased velocity with consequent surge and vibration. Leaks, breakage, and low water pressures may be the prices one pays for the initial economy.

There are three ways to choose an irrigation system. One is to decide how much money is available and then buy the best system obtainable for that amount. Another way is to engineer the best possible system and then spend whatever it costs. The third way is a combination of these two. Design an adequate system with reasonable sprinkler spacings and reasonable pipe sizes together with reasonable flexibility. A conscientious designer can show you how to scale down your extravagant wants to an adequate but more economical system.

Types of systems vary, depending upon area of the country, amount of irrigation needed, water supply available, amount of time available for irrigation, and the availability of labor. The trend is ever toward the use of more automatic systems. Among several reasons for this are:

1. Automation allows the superintendent to control irrigation without depending upon a workman who usually works alone and at night on an unpleasant task.

2. Labor has become scarcer and more costly, and the night water man has to be one of the most intelligent and reliable employees on the staff.

3. Automation allows greater flexibility for handling areas hard to water where runoff and low infiltration rates constitute a problem.

4. All the time available for irrigation (when golfers are off the course) may be utilized. This permits the use of lower precipitation rates and consequently more efficient use of water.

5. Showering in midday to prevent wilting of turf can be accomplished much more easily.

There are some disadvantages to automatic systems. The greatest is higher initial cost. Maintenance costs on the system itself are quite likely to be greater as the components become more numerous and complex.

It seems worth repeating that the irrigation system is the most costly single feature of the course. A complete, adequate, flexible system is complex. The best available professional advice is extremely important.

Maintenance Equipment

To meet the demands of present-day golf course maintenance, the most modern and up-to-date equipment is needed. Maintenance equipment alone will not be the answer at every course; administration, programming, adequate budgets, manpower, responsibility and a host of other elements will be necessary.

The following suggested list should be adequate for the majority of 18-hole courses, although it may not be adequate at many golf courses, depending upon the degree of maintenance:

GREENS AND TEES

6 to 8 putting green mowers
2 power aerators
1 vertical mower
1 power drag mat
1 power topdresser
1 power thatcher
1 power spiker
1 power sprayer (fungicides)
1 proportioner
2 rotary fertilizer spreaders
2 triplex mowers

FAIRWAYS AND ROUGHS

2 seven-gang hydraulic tractors and mowers
1 fairway aerator
1 fairway thatcher
1 fairway sweeper
1 power sprayer (herbicides)
1 rotary fertilizer spreader
1 5-gang mower (roughs)
1 3-gang roller

GENERAL EQUIPMENT

1 or 2 dump body golf tractors
2 general construction PTO tractors
1 jeep, pickup truck, etc.
1 dump truck (5-ton mininum)
1 snow plow
1 front-end loader and backhoe
1 power sod-cutter
1 power saw
1 power stump-cutter
1 power soil-shredder
1 powered hand-sweeper
2 powered leaf-blowers
1 water ballast roller
6 rotary trimmer mowers
3 hand trimmer mowers
2 general purpose power reel mowers
2 or 3 gas powered runabouts

MISCELLANEOUS HAND EQUIPMENT

(This list will go from A to Z.) Axes, burners, crow bar, duster, cup cutter, wheelbarrow, ladder, sod edgers, sod lifters, shovels, rakes, funnels, spade, picks, forks, jacks, pruners, tree saws, traps (animal), pumps, gas cans, scales, pullers, hose, bamboo poles, soil testers, soil probe.

TOOLS FOR REPAIR OF:

All power equipment (trucks, tractors, mowers, etc.), plumbing, drains, electrical equipment, sewers, roadways, cement and concrete, water systems, painting and wood working repairs, etc.

SHOP EQUIPMENT

Lapping machine, air compressor, steam cleaner, table saw, bench grinders, bed knife grinder, reel knife grinder, pipe threader, paint sprayer, welder, drill press, vises, arbor press, work benches.

IRRIGATION EQUIPMENT

Pumping station and number of heads will be determined by the superintendent at each individual course.

* * *

This suggested list has only touched a few of the many odds and ends and pieces of equipment needed. If we may have omitted that one piece of equipment which you feel is necessary, by all means add it to the list.

A maintenance building should meet the following requirements:

1. Superintendent's office (desk, file cabinets, adding machine, etc.)
2. Toilet facilities (showers, lockers, etc.)
3. Adequate heating and ventilation
4. Paint spraying room
5. Herbicide-fungicide, etc., storage room
6. Fertilizer storage area
7. Adequate storage area for all equipment
8. Adequate maintenance area.

In conjunction with the main maintenance building, an additional storage building is essential for storing and mixing of topdressing material. Topdressing should be kept in a dry area so that it will be available at any time of the season. A two-year supply should be stored at all times.

If we have the necessary equipment and maintenance building, how many men will be required to keep the equipment rolling for the necessary turf maintenance? We suggest the following personnel be considered for the average 18-hole golf course in the Northeast:

1 Superintendent (year-round employment)
1 Assistant Superintendent or Foreman (year-round employment)
1 Mechanic (year-round employment)
2 Laborers (year-round employment)
3 Laborers to be hired at the beginning of the outside maintenance program and to be carried through until fall maintenance is completed.
3 Laborers to be hired as summer help

—
11 men total

Regardless of the maintenance building and modern equipment, the work load cannot be carried out unless an adequate work force is available — a work force that can be depended on, day in and day out; men with responsibility to themselves, to the golf course they are working for, and to the equipment they are handling.

Building Golf Holes for Good Turf Management

A CHECK LIST OF ITEMS TO BE CONSIDERED

1. General Considerations
   - A. Site selection
     - (1) Soil types
     - (2) Drainage
     - (3) Vegetative cover
     - (4) Terrain features
     - (5) Former use
     - (6) Availability of water
       - a. Water quantity
       - b. Water quality
     - (7) Availability of power
     - (8) Acreage requirements
   - B. Arrangement of Course Features
     - (1) Accessibility with maintenance equipment
     - (2) Requirements for bridges
     - (3) Requirements for roads on the course
     - (4) Location of the maintenance barn or shop
     - (5) Utility sources and rights-of-way
     - (6) Entrance from public streets or roads to barn or shop
     - (7) Orientation with respect to the sun
     - (8) Orientation of course with respect to clubhouse
   - C. Locations and arrangements of golf course features which affect flow of traffic (foot traffic and golf cars).
   - D. Time required for construction. Do not permit rushing through the building process.

2. Putting Greens
   - A. Location
     - (1) Air circulation requirements
     - (2) Surface water from higher ground to be avoided
     - (3) High enough to drain adequately
     - (4) Shade factors
     - (5) Seeps of subsurface water from higher ground
     - (6) Consideration of traffic approaching and leaving the green
   - B. Design features
     - (1) Slopes
       - a. Both putting surface and surrounding slopes should be subject to maintenance with conventionally - powered equipment
       - b. Sufficient slope to facilitate rapid surface drainage
       - c. Slopes which will carry water from putting surface in several directions (at any rate, water should not all come off the front)
       - d. Slopes must be fair from playing standpoint
     - (2) Contours
       - a. Those on putting surface should permit maximal use of whole area for flagstick placement
       - b. Gentle, sweeping contours add interest without diminishing cup placement areas
   - C. Construction
     - (1) Drainage
     - (2) Soil types
   - D. Irrigation of greens
   - E. Choice of grass
   - F. Collars and aprons
   - G. Preparation for planting
     - (1) Seedbed preparation
     - (2) Sterilization
     - (3) Addition of fertilizers, lime, and other additives
3. Tees
   - A. Sizes
     - (1) Accommodate frequent changes of markers
   - B. Shapes
     - (1) To fit terrain without creation of large steep slopes
     - (2) To fit into traffic flow pattern without creating areas of concentrated wear
     - (3) To permit mowing of elevated tees with gang mower
   - C. Locations
     - (1) With respect to traffic flow
     - (2) Alternate teeing areas
     - (3) Women's tees
     - (4) With respect to shade
   - D. Drainage
     - (1) Surface drainage (slope)
     - (2) Internal drainage
       - a. Soil types
       - b. Tile
   - E. Irrigation
   - F. Choice of grass
   - G. Preparation for planting
     - (1) Seedbed preparation
     - (2) Sterilization
     - (3) Addition of fertilizers, lime etc.
4. Fairways
   - A. Clearing
     - (1) Removal of stumps and debris
     - (2) Removal of stones
   - B. Grading
     - (1) Removal and stockpiling of topsoil
     - (2) Treatment of natural waterways or drainage courses
     - (3) Grading to accommodate operation of maintenance equipment and golf cars
     - (4) To assure adequate surface drainage

(5) Importance of final grading
C. Preparation for planting
(1) Handling of topsoil
(2) Tillage
(3) Addition of fertilizers, lime, etc. based on soil tests.
D. Drainage
(1) Surface (grading or contouring)
(2) Subsurface
a. Tile
b. Catch basins
c. Treatment of outlets
E. Irrigation
F. Effects of trees
G. Effects of parallel or crossing streams and ditches
H. Choice of grass

5. Bunkers
A. Design
(1) Affects mowing
(2) Affects drainage
(3) Affects stability of sand
a. Keeping on steep-flashed banks
b. Keeping it clean
(4) Affects grass on high areas
(5) Affects budget
B. Location
(1) Affects operation of equipment
(2) Affects watering of green
(3) Affects flow of car traffic and foot traffic
C. Drainage
(1) Surface
(2) Tile

6. The Rough
A. Wooded areas
(1) Control of underbrush or other unwanted vegetation to facilitate air circulation, particularly around tees and greens
(2) Removal of stumps and stones in areas which must be mowed
(3) Consider effects of leaves and problem of leaf removal in the fall
(4) Thin trees to permit operation of equipment in areas to be mowed
(5) Ecological effects (on greens, tees, and fairways)
a. Shade
b. Competition for water and nutrients
c. Effect on air movement
B. Cleared areas
(1) Grading
(2) Establishment of required vegetation
(3) Location, spacing and planting of trees to divide fairways, create doglegs, etc.
C. Choice of grass

7. Bodies of Water
A. Creeks
(1) Treatment of banks
a. For stability
b. For control of vegetation
(2) Treatment of tile outlets into creeks
(3) Provision for bridges
B. Lakes and Ponds
(1) Treatment of borders
a. For stability
b. For control of vegetation
(2) Water level control
a. Spillway designs
b. Slope of banks
c. Provision for complete periodic drainage
(3) Ecological effects near greens and tees
(4) The use of bentonite and other soil sealers to prevent seepage
C. Ditches which serve as intermittent water courses
(1) Slope of banks to facilitate mowing
(2) Grade to hasten complete drainage
D. Swamp areas
(1) Feasibility of drainage

(2) Treatment for mosquito control

8. Turf Nurseries
   A. Location of grass and tree nurseries
      (1) Proximity of maintenance shop
      (2) Availability of water
   B. Putting green sod nursery should be planted on soil like that in the putting greens
   C. Sod for tees
   D. Additions of fertilizers, lime, etc.
9. Trees for the Golf Course
   A. Choice of species
      (1) Rooting habit
      (2) Foliage type-leaf nuisance
      (3) Susceptibility to insect and disease
      (4) Susceptibility to ice and storm damage
      (5) Longevity
      (6) Crown shape
      (7) Density of foliage
      (8) Shade
      (9) Height
   B. Location and spacing
      (1) Affected by the above factors
      (2) Affected by maintenance equipment operation
10. Irrigation
   A. Location of water source
   B. Planning the system—This should be done by people competent in irrigation engineering and in proper use of an irrigation system
      (1) Amount of water needed
      (2) Rate of application
         a. Intake ability of soil as related to slope and physical characteristics

For Further Reading

(1) Alderfer, R. B.—Compaction of Turf Soils—Some Causes and Effects. USGA Journal, Vol. IV, No. 2, June, 1951.

(2) Brooks, Cecil R.—Growth of Roots and Tops of Bermudagrass as Related to Aeration and Drainage in Stratified Golf Green Soils. Unpublished Doctoral Dissertation. Texas A & M University, 1966.

(3) Cornish, Geoffrey—Course Construction. The Golf Course Reporter, August, 1958.

(4) Davis, R. R.—The Physical Condition of Putting Green Soils and Other Environmental Factors Affecting the Quality of Greens. Ph.D. Thesis, Purdue University, 1950.

(5) DeFrance, J. A., Simmons, J. A., and Allen, C. H. Jr.—Preparation, Planting, and Developing a Putting Green with Stolons. Rhode Island Agricultural Experiment Station, March, 1950.

(6) Dunning, Bob, et al.—Green Construction. Golfdom, September, 1956.

(7) Dunning, Bob—Full Package Deal for Improved Maintenance. Golfdom, January, 1961.

(8) Ferguson, M. H.—Compaction, Drainage and Aeration. United States Golf Association Journal and Turf Management. 3 (2): 32-33, 1950.

(9) Ferguson, M. H.—Soil Water and Soil Air: Their Relationship to Turf Production. USGA Journal, Vol. III, No. 3, July, 1950.

(10) Ferguson, M. H.—When You Build a Putting Green Make Sure the Soil Mixture is a Good One. USGA Journal, Vol. VIII, No. 6, November, 1955.

(11) Ferguson, M. H.—Soil Modification—Practices With Putting Green Soils. Proceedings 1957 Turf Conference of Midwest Regional Turf Foundation.

(12) Ferguson, M. H.—Soils. USGA Journal, Vol. XII, No. 1, April, 1959.

(13) Ferguson, M. H., Howard, H. L., and Bloodworth, M. E.—Laboratory Methods for Evaluation of Putting Green Soil Mixtures. USGA Journal, Vol. XIII, No. 5, September, 1960.

(14) Garman, W. L.—Permeability of Various Grades of Sand and Peat and Mixtures of These With Soil and Vermiculite. United States Golf Association Journal, and Turf Management 5: Number 1, 27-28: 1952.

(15) Gordon, William F.—Design with Respect to Maintenance Practices. USGA Journal, Vol. XII. No. 2, June, 1959.

(16) Holmes, James L.—Factors in Building A Green. Golf Course Reporter, March-April, 1959.

(17) Howard, H. L.—The Response of Some Putting Green Soil Mixtures to Compaction. Unpublished M. S. Thesis. Texas A & M University, 1959.

(18) Humbert, R. P. and Grau, F. V.—Soil and Turf Relationships. Part 1—USGA Journal, Vol. II, No. 2, June 1949; Part II—USGA Journal, Vol. II, No. 3, July, 1949.

(19) Kunze, J. R.—The Effect of Compaction of Different Golf Green Mixtures on Plant Growth. Unpublished M. S. Thesis. Texas A & M University, 1956.

(20) Kunze, J. R., Ferguson, M. H., and Page, J. B.—The Effects of Compaction on Golf Green Mixtures. USGA Journal, Vol. X, No. 6, November, 1957.

(21) Lambert, L. E.—GCSA Guide for Golf Course Construction. Golfdom, April, 1961.

(22) Lunt, O. R., Miller, P. A., and Wyckoff, C. G.—Seedbed Preparation for Turfgrass. Golf Course Reporter, August, 1955.

(23) Lunt, O. R.—Minimizing Compaction in Putting Greens. USGA Journal, Vol. IX, No. 5, September, 1956.

(24) Lunt, O. R.—Soil Types for Putting Greens. Southern California Turfgrass Culture, Vol. 8, No. 2, April, 1958.

(25) Moote, Robert F.—Golf Course Reporter. September-October, 1961.

(26) Musser, H. B.—Guide for Preparation of Specifications for Golf Course Construction.

(27) Musser, H. B.—Turf Management. 356 pp. McGraw Hill, 1950. Revised, 1962.

(28) Pair, John and Keen, Ray A.—Comparing Percentages of Green Mixtures. USGA Journal and Turf Management, July, 1962.

(29) Phelps, Richard Morgan—The Influence of Planting In Golf Course Design. Unpublished M. S. Thesis. Iowa State University, 1963.

(30) Radko, A. M.—Renovation vs Rebuilding. USGA Journal, Vol. XII, No. 1, April, 1959.

(31) Wolfrom, Clarence—Building and Rebuilding Greens. Golf Course Reporter, July, 1958.

(32) The National Golf Foundation—Planning and Building the Golf Course.

(33) Sprinkler Irrigation Association—Minimum Installation Specifications for Turf Sprinkler Irrigation Systems. 1966.

(34) USGA Green Section—Irrigation of Golf Courses (Symposium). USGA Green Section Record, March, May, and September, 1966.

(35) USGA Green Section—The Putting Green. USGA Green Section Record, March 1968.