USGA GREEN SECTION RECORD

A Publication on Turf Management
by the United States Golf Association

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Long-Range Planning

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COVER PHOTO: The 4th hole at Plainfield Country Club, prior to the 1978 U.S. Amateur Championship.

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The Best Laid Plans . . .

Providing for an adequate supply of reliable, efficient equipment should be a major goal at every club, but it is one that is often found lacking.

by JAMES T. SNOW, Agronomist, USGA Green Section

IMAGINE LIVING day to day with little regard for what may happen tomorrow, next year, or five years from now — a bleak existence, probably, with few alternatives to meet emergencies and no provisions made for maintaining your lifestyle.

Actually, however, we all strive to reach some goal. Can we say the same about golf clubs? It would probably be safe to say that most golf clubs do not have a satisfactory written plan or policy for running of the course and club. Very few successful businesses are developed or maintained without a complete long-range plan. Why should a club, with many employees and a significant budget, be different?

The plan should do much more than deal with capital improvements, although this aspect is certainly important. It should include equipment acquisition and replacement, architectural changes and specific plans for maintaining each area of the golf course. Even though the course may be in perfect shape, a written policy that outlines the successful operations of the program and which provides for future changes is necessary for continuity.

THE PROBLEMS

There are many good reasons for developing a long-range plan. Consider the following problems which could occur unless provisions are made for dealing with them.

Setting Standards

Perhaps the foremost problem is having members who agree about what kind of golf course they want and can afford. They give the superintendent hardly any direction for building a maintenance and development program, and yet when things go wrong the complaints roll in. This often results in unnecessary conflicts between the superintendent and the green committee which may ultimately cause the superintendent to lose interest. On the other hand, the average committee member has very little knowledge of what should be done to the course in terms of maintenance. He doesn't understand why things are done or what happens when problems occur. It is easy to see how frustration and conflict develop during difficult times as the members, by nature, begin to believe that the superintendent doesn't know what he's doing. A long-range program could help resolve these problems, with the superintendent and committee combining to create a complete and comprehensive maintenance and development plan based on the wishes of the membership and the resources they have to offer. This is the first step in planning; it defines goals and sets financial guidelines.

People Problems

Most clubs go through a period when activities are presided over by a well-meaning but aggressive individual in a position of authority for a period and changes the course as a monument to his term. The changes may be new greens, tees, bunkers or plantings of trees that leave an indelible mark on the design of the course. Too often these changes don't fit the course theme and character. Design work is best left to a qualified architect, someone trained to protect the integrity of the original design and to bring out the best of what is available. Problems of this nature can be avoided with a long-range program which includes changes based on the advice of a golf course architect, with variations possible only upon the approval of the committee and/or architect.

Changes in the Green Committee

Many clubs have a policy that limits the green committee chairman to a brief term in office, usually two years. He then leaves the committee. As the new chairman takes office, he usually has little idea of what is involved in the total maintenance operation or what should be expected from the golf course superintendent. By the time he learns it is time to leave office, and the next fellow has to learn it all from scratch. This is difficult for both the superintendent and the green committee chairman.

On the other hand, the green committee chairman is responsible to the membership and therefore must be in frequent contact with the superintendent on course operations. Since usually he has no training in golf course management, friction may develop between him and the superintendent, who sometimes mistakenly believes the green committee chairman is questioning his knowledge and authority.

Here is where a long-range plan would benefit everyone. A comprehensive plan would list all course maintenance programs and their purpose. The green committee chairman, or any other member for that matter, could refer to the plan and immediately know what is being done and why. The superintendent would not have to spend so much time explaining and justifying his programs.

Change of Superintendent

The change of a golf course superintendent is something of a traumatic experience at many golf clubs. The selection committee, usually untrained in golf course operations, has nothing on which to base a decision except for intuition and seeing how each prospective superintendent sells himself. The successful applicant is not necessarily the most knowledgeable and the best qualified. With a comprehensive plan, however, the committee would be better able to determine the most qualified applicant. The committee would have a good idea of what to expect from the new superintendent, and with a complete record of past programs available to him, the new man would be in a good position to recommend positive changes based on past successes and failures.

Serious Turf Problems

Despite the excellence of their maintenance programs, even the best golf courses will suffer losses of turf under extreme conditions, usually because of the weather. This problem can be very frustrating for both the superintendent and for the golfers. Members can't understand how such a disaster can happen, and the superintendent is criticized, a sad commentary on the communications channels and public relations efforts at so many clubs today. This could be avoided with a long-range plan developed by the superintendent and the green committee. Such a plan, outlining the best steps to take to avoid such injury (and approved, of course, by the committee), would be of tremendous value if winter injury were to occur again.

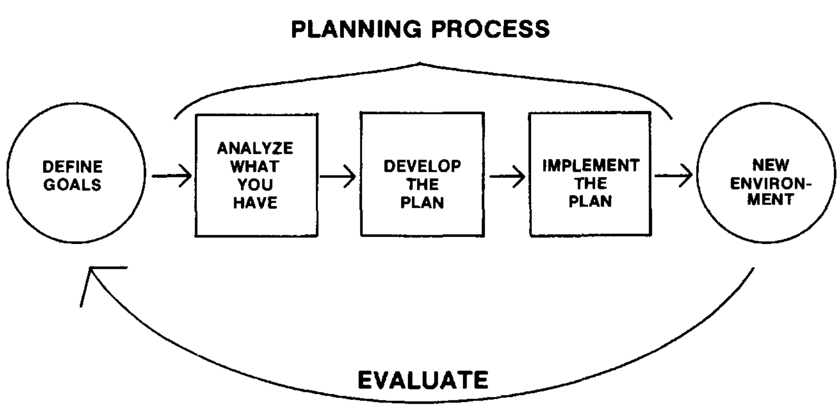

Figure 1. A schematic outline of the general planning process. It provides a systematic approach to problem solving and long-range planning.

What kind of golf course does your membership want? A highly manicured, consistently uniform course will cost more than the "natural look."

These are just a few of the problems golf courses throughout the country face each year that could be resolved with a long-range plan.

THE PURPOSES OF A LONG-RANGE PLAN

(A) To improve the physical facilities of the golf course in an orderly manner in order to make it more beautiful, functional, interesting and efficient.

(B) To promote the interests of the entire membership rather than of a few individuals or special groups within the club.

(C) To effect coordination and improve communications with regard to course development and maintenance, so as to avoid conflict, duplication and waste.

(D) To ensure that short-range actions are considered in the context of long-range goals.

(E) To bring professional and technical knowledge to bear on the decisions based on the wishes of the members. The professionals may be the superintendent, architect, agronomist or other consultants.

WHO IS RESPONSIBLE FOR DEVELOPING A PLAN?

The responsibility for initiating and developing the plan may fall to the superintendent, green committee chairman, president, manager, golf professional or someone else in authority. Because the superintendent makes his living through the club and has perhaps the most to gain, he should pick up the ball and carry it. It must be stressed, though, that input into the plan should come from many sources. The plan must represent the wishes of the entire membership.

Various clubs have different procedures for formulating the long-range plan. Often the superintendent and the green committee will work together, with the superintendent providing technical information and forming the basic plan based on desires and goals of the committee. Other clubs have a long-range planning committee, separate from the green committee. This L.R.P. committee may be more practical at clubs with a variety of activities, such as golf, swimming, tennis and platform tennis, where a long-range plan would include all these activities and the green committee would have only limited input.

Regardless of the mechanisms your club uses to form its plan, it will take hard work by many people to develop a comprehensive plan which will serve everyone's best interests. There must be committee members who are willing to sacrifice some time to provide the critical information on which the superintendent can base his program. The committee should be willing to invest some money so that the best technical information and evaluation can be provided. The superintendent will provide the bulk of this information, but others, such as architects, agronomists, engineers and other experts, should be consulted. No one person can be expert in every area of a long-range plan. Finally, there is no such thing as a complete and final plan; many changes will occur from day to day and year to year. Therefore, there must be a commitment by the superintendent and the green committee to analyze and revise the plan on an annual basis, or else it will lose its value.

THE BASICS OF A LONG-RANGE PLAN

A well-defined process has developed by which a plan is designed. It offers a systematic approach to meeting your long-range goals and needs, and it should act as a model for you as a long-range program is developed for your course.

Figure 1 shows the planning program broken down into several basic components. What this says is that (1) the goals and needs of the members are defined, (2) the planning process is carried out, and this results in (3), a new environment, the realization of your goals. The situation is then periodically evaluated, and this may lead to the development of new goals and plans. As you can see, the long-range plan is a continuous system which always provides for necessary changes.

Define Your Goals

This is a critical step in the planning program, for how can a plan be designed without knowing the members' goals and objectives? The superintendent may be of some assistance with this step, but here is where the members should provide the most input. After all, the club exists for their enjoyment, and they are paying the bill. The goals and objectives should be general in nature. For example, one goal might be "to produce tees which are adequately large, low cut, level and firm." Objectives should *not* be so specific as "the 7th and 16th tees should be rebuilt because they are too small." This specific problem will be picked up and resolved in the "Analysis" and "Design" steps.

As suggested in Figure 1, the planning process itself can be broken down into three general components:

Analyze What You Have

This is a time-consuming, step-by-step analysis of every phase of the operation. Included as general areas of interest are greens, tees, fairways, bunkers, landscape, equipment, buildings, irrigation, tennis courts, swimming pool, etc. Analyze each area and consider alternative solutions to the problems as you go along. For example, "the area over the irrigation line on the 12th tee is sunken and may be corrected by removing the sod, adding topsoil and replacing the sod so that it conforms to the remainder of the tee. Frequent topdressing would also resolve the problem but would take longer to complete."

The responsibility for the analysis phase should be shared by the superintendent and the committee, with the superintendent carrying the heavier load.

Develop The Plan

Based on your analysis of every phase of the golf course or club operation, the long-range plan should be developed. Specific plans for each project should be completed, along with comprehensive cost estimates and time schedules for their completion. An overall timetable for capital improvements and equipment acquisition must also be worked out, based on the resources of the club and allowing for who will be doing the work. Outside contractors often will do much of the construction work, though the superintendent and his crew may handle a large portion of this if time and labor allow.

Recommendations for regular maintenance procedures should be finalized and incorporated into the plan. If the members have been satisfied with the course to this point, these maintenance procedures will be nothing more than what has been done for years. However, now it will be written down as part of the long-range plan, to be referred to by the superintendent, committee members or others as the need arises.

Implement The Plan

The implementation phase simply involves following through with the plan as you have designed it.

Strive for a dependable on-site supply of irrigation water to cope with drought or purchased water shortages.

Regarding capital improvement work, details should be completed according to the time schedule, including the finalization of drawings, specifications, bids, etc. The decision as to who will do the work is again worth mentioning. Often the superintendent and his crew will be given the responsibility for such capital improvement work as building greens, tees, bunkers, bridges, installing cart paths, irrigation systems, etc. Too often they are expected to maintain the golf course in top condition and work on these projects at the same time, with no increase in the size of the crew. What often happens is that the appearance and playability of the golf course suffers, and the projects are not completed on schedule. This situation works out poorly for everyone involved, and so provisions must be made to increase the size of the crew during periods of capital improvement work, or else offer the work to contractors outside the club.

Some of the points which will be considered as you develop a long-range plan are illustrated below. This example of a long-range plan for greens is necessarily brief and omits many of the details which would ordinarily be included. However, it should give you the general idea of some of the points that have been discussed thus far. These goals could differ from club to club.

A LONG-RANGE PLAN FOR GREENS

Goals

(1) To develop consistently fine greens with a high percentage of bentgrass, good density and fine texture.

(2) To maintain uniform surfaces to the desired speed.

(3) To maintain resilience in the soil so that a well hit golf shot will stay within a reasonable distance from the spot where it lands.

(4) To maintain the character of the architectural design in the mowing pattern of the surface outline.

Analysis

(1) All greens contain too much *Poa annua*.

(2) Grain is a problem at certain times of the year.

(3) There is no turf nursery for repair work.

(4) Greens No. 3, 8, 9, 17 do not provide adequate surface drainage.

(5) Shade and tree root competition result in weak turf on greens No. 7 and No. 17.

(6) There is poor irrigation coverage on green No. 12.

(7) Winter injury is an annual problem on green No. 17.

Recommendations

(1) As part of the routine maintenance program, the greens will be: (a) cut daily with the appropriate equipment at 3/16 inch, (b) aerated in the spring and fall to reduce soil compaction, (c) verticut lightly twice monthly, weather permitting, to prevent excessive grain, and (d) topdressed monthly with a material meeting USGA specs in order to produce a smooth, firm, resilient surface.

(2) Overseed all greens with an appropriate bentgrass twice annually, at the time they are aerated, to increase the percentage of permanent grasses.

(3) Establish a putting green nursery for the purpose of repairing the greens. It shall be maintained in the same manner as the other greens. Cost — $1,000.

(4) Provide adequate surface drainage on greens No. 3, 8, 9 by lifting sod, regrading subsurface and replacing sod.

(5) Rebuild green No. 17 according to USGA specifications. Retain a golf course architect to redesign green. Approximate cost — $13,500.

(6) Relocate irrigation heads around No. 12 green to improve coverage.

(7) Root-prune trees around greens every three years.

Again, this is only a brief outline of the type of plan you might develop for the greens. In addition, similar plans would then be designed for other areas of the course and other aspects of the total program. For example, you might have long-range plans for each of the following general topics:

Greens	Irrigation System
Tees	Drainage
Collars	Equipment
Fairways	Buildings
Roughs	Cart Paths and Traffic Control
Bunkers	Swimming Pool
Trees and Landscape	Tennis Courts
Practice Areas	

THE BEST LAID PLANS . . .

Despite the best efforts of the superintendent and committee to bring everything together in a comprehensive plan, things will be left out and the circumstances surrounding any particular situation may change with time. Therefore, the final and continuing phase of the long-range plan is to periodically evaluate the plan and see what it has produced. If things are not as they should be, new goals may need to be defined, new analyses made, and new recommendations incorporated into the plan. The evaluation phase is critical, and the best plan ever created would be worthless without it. A formal evaluation on an annual basis is a popular schedule, as this allows enough time for some progress to occur yet is frequent enough to keep the interest of the superintendent and committee.

Many things should be considered in the development of a long-range plan, and it certainly cannot be done overnight. It may take months or even years to create a comprehensive plan that serves the best interests of the club, its members and its staff. It gives the members the opportunity to set the standards for the maintenance and development of their course to best suit their skills and desires. It gives them a reference point as to what should be done on the course, but it also realistically limits their expectations according to what they can afford and what resources they provide for the superintendent and crew. The important point is that they understand the situation in advance so that disappointments and conflicts can be minimized. The long-range plan gives the superintendent a set of goals which seems real and definite, not an abstract cloud of complaints and compliments from several hundred individual members. It leaves the responsibility of setting standards and finding resources to the committee of members, where it should be. It eliminates many potential areas of conflict, some of which could find the superintendent's job on the line.

The long-range plan offers valuable dividends to everyone at a golf course. It takes a good deal of hard work to create, but what item of value doesn't? It is something that *every* club should develop.

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The Stimpmeter and the Open

by FRANK THOMAS,
USGA Technical Director

After four consecutive days of double-mowing at championship setting, note excellence of texture and putting quality.

SUPERINTENDENT JIM YOUNG did an excellent job in bringing Cherry Hills Country Club to peak championship condition for the 1978 U.S. Open Championship. Despite difficult Colorado weather prior to and during the tournament, the course condition was super and greens in particular were superb. Ably assisted by Tim Sedgley and a young crew of eager, interested and cooperative young men, most of whom were students or college graduates, things ran smoothly despite the usual day-to-day problems that are sure to occur when a major tournament is in progress. Young's ability to organize and delegate authority prevailed, but his fine sense of humor made this championship enjoyable for all who came in contact with him.

To achieve championship uniformity and speed on putting greens, Young's program was as follows:

1. Little fertilizer was applied — only ⅛ pound nitrogen per 1,000 square feet was applied in the spring prior to the championship. Carefully conditioned hungry turf makes for better championship putting surfaces.
2. Iron is applied periodically during the year. High sodium soils require periodic treatments with ferrous sulfate and chelated iron. One treatment was applied during the week of the Open.
3. The normal summer watering program requires 20 minutes each night; during the Championship the program was altered as follows:

   Tuesday night — 10 minutes to all greens.

   Wednesday night — 10 minutes to all greens.

   Thursday night — 10 minutes to all greens except for No. 1, No. 4, No. 14 and No. 16, which were softer than others. They were watered only five minutes.

   Friday night — all greens watered 15 minutes.

   Saturday night — all greens watered 15 minutes except No. 4, 14 and 16, which were watered 10 minutes.

This schedule may surprise some people who are knowledgeable in turfgrass management, since this normally would be considered a heavy watering schedule in other regions. However, the soils and water supplied in this region are high in sodium, which causes a breakdown in soils, increases compaction and limits water penetration — hence the need to water more. Secondly, the temperature for this week was in the 90s, the sky was cloudless for most of the week, humidity was low and 15- to 20-mile-per-hour winds blew incessantly on some days. This combination causes surface water to evaporate rapidly and close-cut putting green grasses to wilt. Therefore, every green had to be syringed shortly after noon every day. Despite this schedule, greens were tournament firm.

THE MOWING SCHEDULE

All greens were double-cut beginning on Wednesday morning. Speed tests daily indicated that it took four consecutive days of double mowing to attain the desired uniformity and speed; therefore, in the future, all greens will be mowed so that the fourth consecutive double-cutting will take place the morning of the last practice round, if this can be safely accomplished. Because of the high temperatures at Cherry Hills, Young was afraid that some turf would be lost on greens late in the week if they were double-cut too early.

Single unit rigid mowers were used set at 5/32nds the week prior to the Open, at 9/64ths for Monday to Thursday and at 7/64ths according to Young for the Friday, Saturday and Sunday mowing.

Stimpmeter readings were taken on every green every morning between 15 and 20 minutes before play, keeping well ahead of the field. In many cases more than one reading was taken on some greens to check the consistency of different zones. In general, this is not necessary. In this case, however, the data exposed a problem which might not have been corrected without multiple readings. On one day, greens were tested following the final group in the afternoon to confirm previous findings regarding changing speeds of greens during the day. These tests confirmed that there was relatively little change in speed during the day. This can be attributed to the two opposing factors which influence the speed of the green.

In general, as the greens dry they may become a little faster. During the day, however, the grass continues to grow, and this is inclined to decrease speeds. These two factors are therefore counteracting one another. It depends upon which of the two is dominant as to which way the change will be. However, the change at the end of the day tested was slower, but no more than 6 percent slower than when play started. One cannot conclude from this that the relationship between these two opposing forces is linear throughout the day. For example, a quick-drying spell in the early morning may have a rapid speeding-up effect on the green before the growing grass can slow it down. Greens sheltered from the wind may not be affected as much as exposed greens.

Syringing of the greens also has an affect on the putting surface, but not nearly so dramatically as we anticipated. Preliminary tests have shown that if syringing is done correctly and those conditions requiring syringing prevail — i.e. reasonably high temperatures and drying winds — within five minutes after the syringing, the putting speed is virtually identical to what it was before syringing. The preliminary tests showed that even though approximately five minutes was required to regain the putting speed, only two and one-half minutes was required for the speed to return to within 5 percent of the original speed prior to syringing. This information should not be misused, because it depends upon a number of conditions — first, that the syringing is done correctly; second, that the conditions requiring the syringing prevail after it has been done; and third, the analysis cannot be considered conclusive since data was gathered from one location only.

When we tested the Cherry Hills greens with the Stimpmeter, we experimented with a golf ball with no dimples. This ball gave us repeatable readings, and yet when we compared them with the data we gathered using regular dimpled golf balls, we found them to be no longer or shorter on the average.

SPEED AND CONSISTENCY

The chart below shows the green speeds Wednesday through Sunday, the final day of the Championship. These are averages and include the measurements made on the practice greens.

It can be seen from these figures that the greens were in the medium-fast range for championship conditions during the final two days. However, this does not imply that the faster the greens the better. One should understand that generally a fast green presents a better putting surface and, therefore, a truer test of one's skill. However, one must seek to achieve consistency of the greens over the entire course.

GREEN SPEEDS
STIMPMETER READINGS — 1978 U.S. OPEN

Last Practice Round	First Round	Second Round	Third Round	Fourth Round
Average 8′ 8½″	8′ 11½″	9′ 4¼″	9′ 5½″	9′ 7¾″

Speeds for Tournament Play

10′ 6″	Fast
9′ 6″	Medium-Fast
8′ 6″	Medium
7′ 6″	Medium-Slow
6′ 6″	Slow

It can be argued that a true champion should be able to determine the speed of the green for himself and that, therefore, making greens consistent in surface texture and speed takes something away from the game. Unfortunately because greens are mowed and maintained in the condition they are today, it is almost impossible for anybody to determine differences in speeds from visual inspection. Also, the Rules of Golf prevent him from using his sense of touch to test the texture of the grass.

If the condition of golf courses had not changed in the last hundred years because of advances in management practices and turfgrass research, then possibly there would be no reason for the Stimpmeter. However, courses have changed, and because course conditions are so good, we should try to present the players with similar conditions with regard to surface texture. Course architecture is therefore playing an increasingly important part in maintaining the challenge a golf course should offer. A well planned and executed shot should be rewarded.

During the last round, the average speed was 9 feet, 7¾ inches; 68 percent of the greens were within plus or minus 3¾ inches of the average, and 95 percent of the greens were within plus or minus 7 inches of the average. We consider this adequately consistent, the result of Young's close scrutiny each day of the Stimpmeter readings and his modification of the mowing and watering schedules.

Mowing procedure was also modified slightly. The first green at Cherry Hills, for example, features a large dip or valley across the front part of the green, rising to a plateau section towards the back. Either section could be used for hole locations. Wednesday's Stimpmeter measurement showed the speed of the front section to be approximately 9 feet; the back area was almost a foot slower. There was no apparent reason for this, although it did present a problem. Young, in consultation with USGA agronomists on the scene, decided to triple-cut the back section of the green on the mornings of the first and second rounds. On the final day of the Championship the back section of the green was still a little slower than the front, but only by two or three inches.

Prior to the 1978 Open at Cherry Hills, the Stimpmeter was used and measurements made for educational purposes. However, at Cherry Hills the data was actually used to manipulate and modify preparation of the greens and thus present the fairest challenge possible to every competitor.

A note of caution should be added. Readings of from six to seven feet are perfectly adequate for regular membership play; emphasis should be given to consistency rather than speed. If one attempts to maintain a green at speeds over nine feet for everyday play, it can become extremely costly because of the manpower required.

We must keep in mind that the lifeblood of golf is the challenge it offers; however, this challenge should be fair and one's ability to return a good score should not depend to any major degree upon luck. Having presented the player with virtually a perfect undulating green on which to putt (whether it is good or bad for the game is a subject for debate), we have taken away the contrast which previously allowed him to determine the speed of each green he approached. The Stimpmeter allows us to give something back that we have taken; however, there are other areas where advances in technology may be taking some of the challenge from the game and these must be carefully considered and with advanced technical standards controlled.

Fighting fire with fire.

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Robert Sommers, Managing Editor

A GREEN SECTION SUPPORTED RESEARCH PROJECT

A Machine for Cleaning Sand Bunkers

by **BRAHM P. VERMA,** Associate Professor, Department of Agricultural Engineering
University of Georgia, Georgia Experiment Station, Georgia

REMOVAL OF TRASH or foreign materials from sand bunkers is an essential maintenance chore for golf course superintendents. A machine that quickly and efficiently removes trash from bunkers has been developed. It effects a small degree of separation by using narrow belts spaced a preset distance apart and driven by rotating circular pulleys. With this arrangement, material on the bed of moving belts that is smaller than the space between the belts should fall through and the remaining material will be carried to the end of the bed. There are two major problems with this arrangement.

(1) When small particles are on the top of the larger particles, they are carried on to the end of the belt without being separated, and

(2) At certain moisture contents, sand particles will adhere to each other and not be separated.

This problem can be solved if vibration is provided so that the position of the particles on the belt is changed and the force of adhesion is overcome to disperse sand particles.

A pulley-belt mechanism was developed in which pulleys of non-circular cross-section were successfully used to transmit vibration to the belts. Pulleys of any constant width closed curve* can be used, provided that the two pulleys are of the same shape and size and that the two pulleys are in time. Figure 1 shows the pulley cross-section and Figure 2 illustrates the positions when the two pulleys are in- and out-of-time.

CONSTRUCTION OF THE TEST CLEANING BED

Two pulleys of constant width triangular cross-section (Figure 1) were constructed by the following procedure:

Start with an equilateral triangle ABC, where AB=BC=CA=1 inch and extend the three sides in both directions so that AD=AE=BF=BG=CH=CI= 0.375 inch. Then construct three arcs FI, EH, and GD with the compass point at A, B, and C, respectively. Similarly, draw three arcs DE, GF, and HI with centers at A, B, and C, respectively. The resulting closed figure is a constant width triangle and is the desired cross-section for the two pulleys.

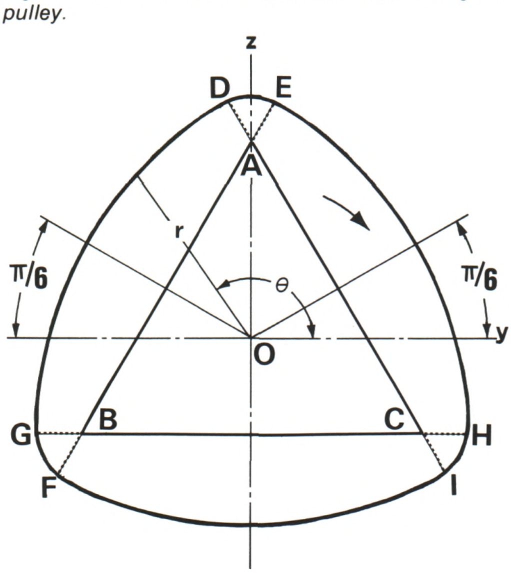
To construct these pulleys in a practical manner, make nine punch marks on four 2 x 2 x ½ inch flat metal pieces outlining the periphery of the constant width triangle. Drill ¼ inch diameter holes at the punch marks on the four metal pieces. Then insert ¼ inch diameter steel rods 13 inches long into the holes of a pair of the metal pieces using them as end caps. Welding the rods to the caps forms a 12-inch wide pulley of the desired configuration (Figure 3).

A 12-inch wide by 18-inch long cleaning bed was made by using the two pulleys and 26 3/16-inch diameter round nylon belts. The belts were spaced 3/8 inch apart, center-to-center. Chain and sprockets of the same size, on each pulley shaft, were used to keep the pulleys in time during operation.

EXPERIMENTAL DESIGN AND PROCEDURE

A laboratory experiment was designed to test the separating efficiency of the curved triangular pulley-belt system. The cleaning bed was mounted

Figure 1. Cross-section of constant width triangular pulley.



*Constant width closed curves possess the property in which the distance of any two parallel tangents are always at the same. Circle is only one such shape. For details see references Gardner, 1963, and Verma, et al., 1977.

at the end of a conveyor belt with an arrangement so that a sand and trash mixture from the conveyor belt could be dropped on the cleaning bed at a predetermined rate. The cleaning bed pulleys were driven by a variable speed motor.

The following conditions were tested to determine the separating efficiency of the design:

1. Five Pulley RPM: 50, 100, 150, 200 and 250 RPM.
2. Three cleaning bed inclinations (angles from horizontal plane): 0 degrees, 10 degrees and 15 degrees.
3. Two sizes of gravel to simulate trash: (a) ¼ to ½ inch and (b) greater than ½ inch.

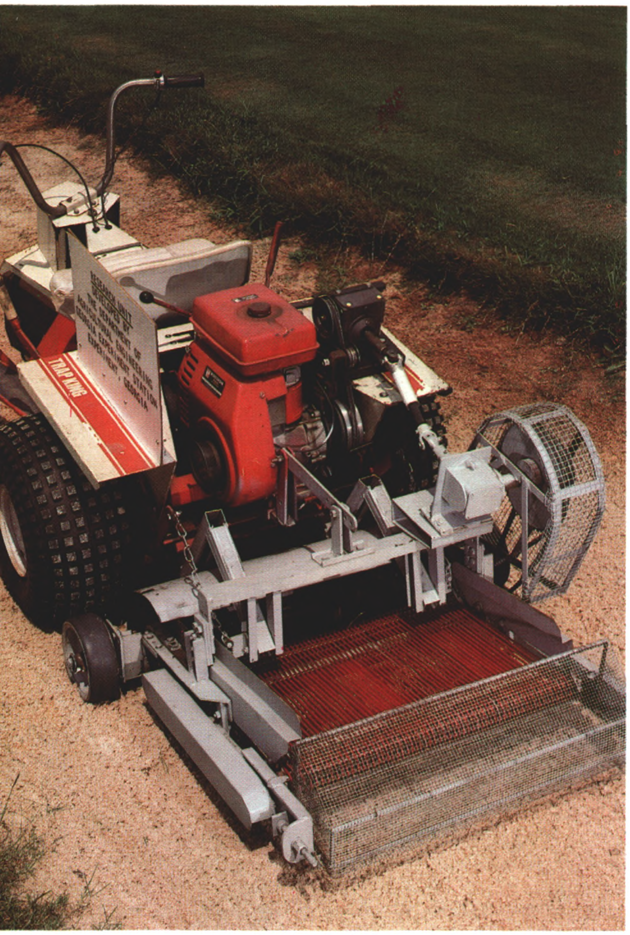


Figure 4. The bunker sand cleaning unit above and the reason why it's needed on the right.

Figure 2. Schematic of constant width triangular pulley-belt arrangement. (A) Pulleys in-time. (B) Pulleys out-of-time.

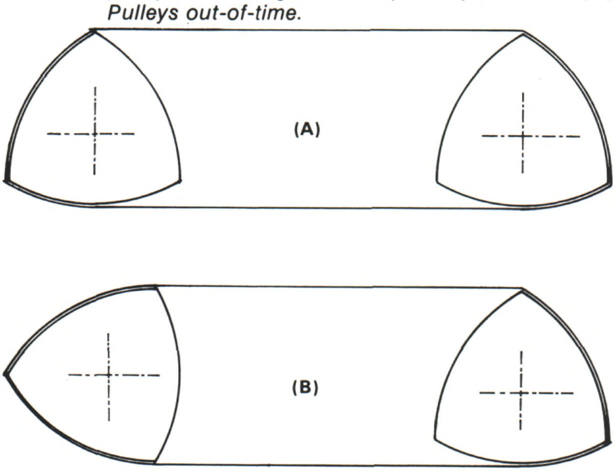
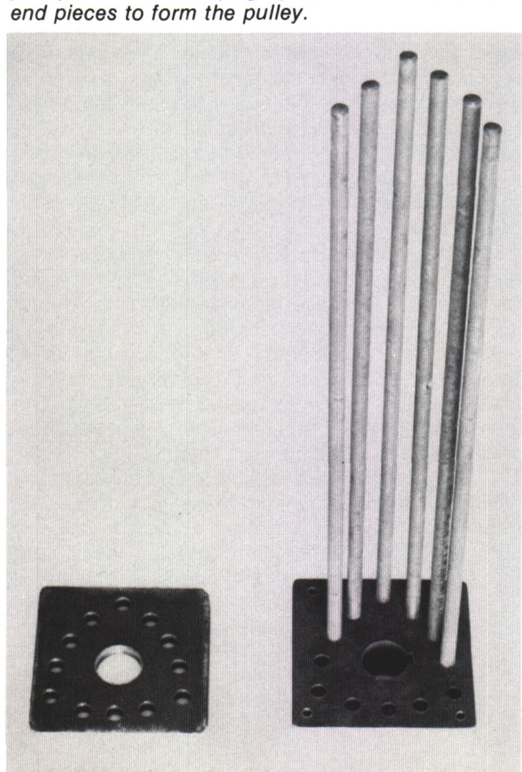


Figure 3. Construction of pulleys. (Left) Pulley end piece with ¼-inch holes outlining the triangular pulley cross-section. (Right) Steel rods between the end pieces to form the pulley.



4. Three rates of sand and gravel mixture fed onto the cleaning bed by the conveyor belt set at ½ mph linear speed to provide sand thicknesses of: (a) ½-inch thick sand and gravel mixture, (b) 1-inch thick sand and gravel mixture, and (c) 1½-inch thick sand and gravel mixture. Assuming the bunker cleaner is set to pick up a layer of sand ¼ inch deep, the above conditions simulate operating speeds of 1, 2, and 3 mph.
5. Two sand moisture contents: (a) dry sand and (b) moist sand.
6. All tests were replicated twice. Some preliminary tests indicated that the most satisfactory mode of operation was to introduce a pre-weighed amount of sand and known number of gravel particles on the cleaning bed. Therefore, 10, 20, and 30 pounds of sand was introduced at ½, 1, and 1½ inch thickness, respectively. With the sand 50 large and 100 small gravel particles were mixed. The sand and gravel were collected at three locations: (a) under the first half section of the cleaning bed, Section 1, (b) under the second half section of the cleaning bed, Section 2, and (c) at the end of the cleaning bed, Section 3.

RESULTS AND DISCUSSION

Data from the laboratory tests were analyzed to determine design criteria for best cleaning. The cleaning efficiency was determined by: (a) the separation of sand from gravel with collection in Sections 1 and 2, (b) the conveyance of large-gravel to the rear with collection in Section 3, and (c) the conveyance of small-gravel to the rear with collection in Section 3. For the best performance, 100 percent sand and no gravel should be collected in Sections 1 and 2, or 100 percent of the gravel of both sizes and no sand should be collected in Section 3.

The first set of tests was run using dry sand. For all operating conditions, 100 percent of the sand and 100 percent of the large gravel was separated. However, the small gravel separation was dependent upon the pulley RPM. As the pulley RPM was increased, more small gravel particles were conveyed to the rear, and at a 10 degree bed angle and 150 pulley RPM, 99 percent of the small gravel was transported to the rear of the cleaning bed.

Test results with the moist sand show that, in general, the sand separating efficiency increases as the pulley RPM are increased at all three bed angles. However, the small-gravel transporting efficiency decreases with increase in pulley RPM from 50 to 150 RPM and then increases as the pulley RPM is further increased to 250 RPM. The large-gravel transporting efficiency was 100 percent for all test conditions.

To determine the best operating condition, the overall cleaning efficiency was calculated by multiplying the sand-cleaning efficiency and the sand-gravel transporting efficiency. It was found that the best cleaning was obtained at 250 pulley RPM, 0 degree bed angle and ½ inch sand thickness. It appeared that the bed angle had little effect at 250 pulley RPM and ½ inch sand thickness.

THE FIELD UNIT

Based on the results of the laboratory test, a field unit with a cleaning bed 18 inches long and 24 inches wide was made, using the curved triangular pulley and belt system. The cleaning unit was mounted at the rear of a Trap King* bunker tractor (Figure 4). In front of the cleaning bed, a sand pick-up unit was mounted. The pick-up unit was made by using six, 6-inch square blades mounted at a 45-degree angle on a shaft. A shield was constructed to direct the sand and trash onto the cleaning bed. The pick-up unit rotated backwards, i.e., reverse to the direction of rotation of the tractor wheels. A collection basket made with ¼-inch hardware cloth was mounted at the rear of the cleaning bed and provision to vibrate it was made.

The unit works well when the sand is not wet and where the depth of cut is such that the sand entering the cleaning bed is not excessive. We have recorded 100 percent sand separation and trash transportation under good operating conditions. However, we have found that the pick-up unit is unable to pick up all trash and deposit it on the cleaning bed. Improvement in the design of the pick-up unit is recommended.

CONCLUSIONS

We have successfully demonstrated that the constant width curved triangular shaped pulleys can be used in a pulley-belt system for separating trash from sand. Pulleys of such cross-section can provide the necessary vibration to materials for size separation. A field unit was constructed using the new separating mechanism which performed well when sand was not wet.

ACKNOWLEDGEMENT

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TURF TWISTERS

THERE IS A DIFFERENCE

Question: Is there a difference in wetting agents that are used in turfgrass management? (Iowa)

Answer: Ionic wetting agents are phytotoxic and some may even affect soils. Nonionic wetting agents are normally used. These materials are bio-degradable; they will not build up in the soil. They also reduce bulk density and soil tension.

TOPDRESSING WITH

Question: What makes topdressing work? (Massachusetts)

Answer: The most important effect appears to be the physical alteration of the thatch microenvironment, best achieved by keeping the topdressing material intimately intermingled with the thatch through frequent, light applications.

SALT

Question: Our golf course is situated next to a college that enjoys a large enrollment. In recent years, the school enlarged its parking area which drains onto our property and into our irrigation pond. Our problem concerns the heavy use of salt on roads and the parking lot to melt the ice in winter. Will salt have a detrimental effect on our irrigation water? If so, what can we do about it? (New York)

Answer: Without question salt will have a detrimental effect on your golf course soil and turf. Sodium will not deteriorate; therefore, it will accumulate in the pond. Also, high concentrations will impair turf quality; sodium also causes a breakdown in soil structure. It will be especially harmful when your pond level is low and the sodium concentration is high.

It would be most helpful to your predicament if you could persuade the college officials to switch to urea or calcium chloride in place of sodium chloride to melt the ice on their parking area and roads.