A GREEN SECTION SUPPORTED RESEARCH PROJECT

Mechanizing Trash Removal from Sand Bunkers

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Poor maintenance of sand bunkers can sorely degrade the appearance and playing condition of a golf course. Efforts to minimize cost and labor requirements while maintaining good quality trap conditions have resulted in sand bunker modifications making them suitable for mechanical raking. Some golf course superintendents, however, continue to face trashy trap conditions that are not remedied by mechanical raking.

Wind blown debris, player-dropped trash, and gravel rising from beneath the sand pose trash problems in bunkers. To-date methods and machines for mechanically gathering trash from bunkers have not been available to golf course superintendents. A research project at the Georgia Experiment Station (of the University of Georgia College of Agriculture), funded in part by the U.S.G.A. Green Section Research & Education Fund, Inc., is partially directed toward providing a machine that will rid sand bunkers of the undesirable trash. The objective of this research is to develop a machine that will remove trash 1/4 inch in diameter or larger from surface layers of sand and leave a surface that is pleasing in appearance and conducive to play.

CLEANING PRINCIPLE

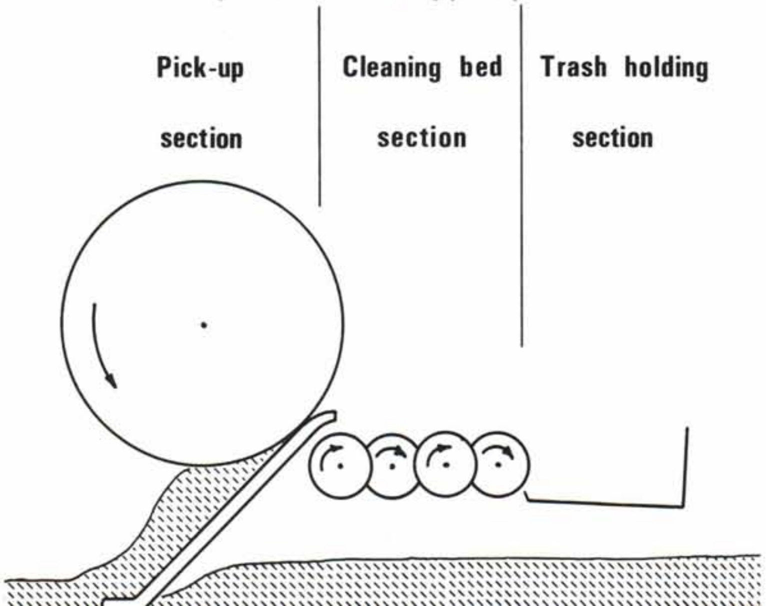
Trash that hinders play or degrades the appearance of bunkers can be on the sand surface or either partially or entirely buried in the surface layer of sand. Therefore, the cleaning unit must collect not only that trash at the sand surface but also that within the surface layer.

The principle selected for use in the cleaning unit includes elevation of the surface sand layer, removing the trash, and returning the sand to the bunker. The basic cleaning principle is illustrated in Figure 1. As the cleaning unit moves forward (to the left in the figure), the sand layer is elevated and passed over the cleaning bed where trash separation occurs. Trash is then conveyed to the holding section while the sand falls back onto the surface below.

The pick-up section of the cleaning unit serves to penetrate the surface layer of sand and transport the sand and trash mixture to the cleaning bed. The pick-up section, when using spaced tines to penetrate the sand, provides some trash separation by allowing sand to pass between the tines and fall to the sand surface below. Rotating brushes above the tines assist the movement of the sand-trash mixture (that which accumulates at the tines) back to the cleaning bed section.

The cleaning bed section is the primary mechanism for separating trash from the sand. The cleaning bed is composed of parallel shafts rotating opposite to ground wheel rotation during forward travel.

Figure 1. The cleaning principle.



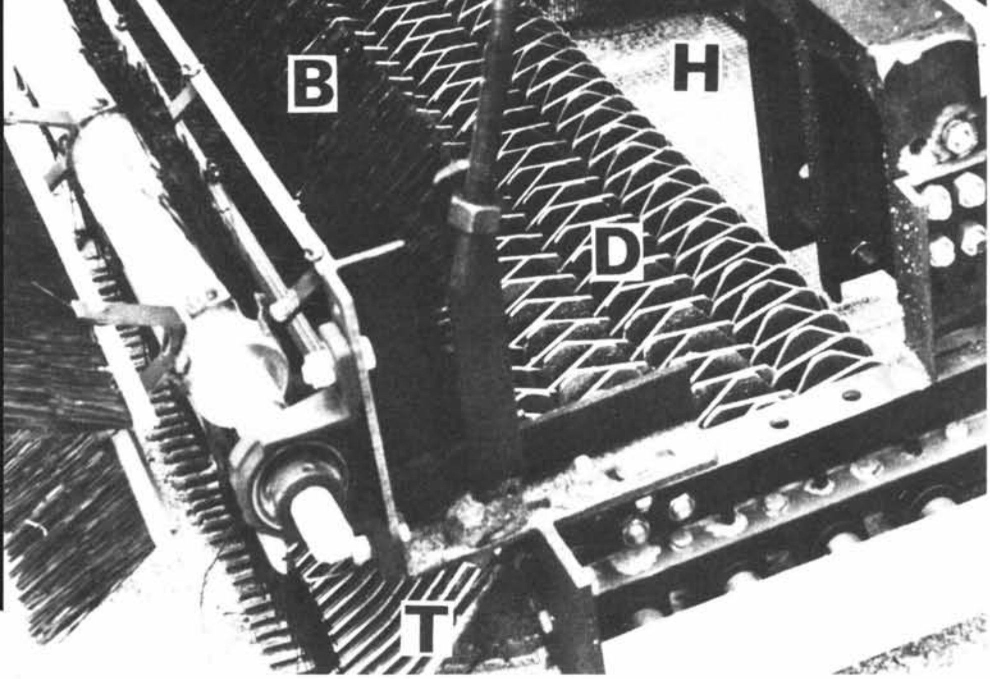


Figure 2. The cleaning unit showing brush (B), discs (D), trash holding basket (H), and the tines (T).

Fastened to and equally spaced on each shaft are thin discs that overlap with those on adjacent shafts. Separation of trash from the sand-trash mixture reaching the cleaning bed occurs as the sand falls through the discs to the exposed sand surface below and the trash having dimensions greater than the disc clearance is carried over successive rows of the rotating discs to the trash holding section.

The trash holding section serves as a collection point for all trash passing through the pick-up section and over the cleaning bed. A removable basket, one that allows small quantities of retained sand to sift out, is used to hold the trash until a sufficient quantity has been collected to require emptying. Alternatively, a conveyance device replacing the basket could carry trash away from the cleaning bed.

MACHINE DEVELOPMENT

Development of the sand cleaning unit has progressed through three stages:

1. Construction of a cleaning unit for laboratory evaluation of the cleaning principle.
2. Construction of a portable power unit and modification of the cleaning unit for use in a sand bunker and
3. Evaluation and refinement of the cleaning unit for improved performance.

The first cleaning unit was constructed to clean a 12-inch wide strip of sand for laboratory evaluation of the cleaning principle. The cleaning unit was placed in a test apparatus that could provide to the pick-up section a 2-inch deep layer of sand at various travel speeds. As trash (1/4 to 1-inch maximum diameter wood, rock, and paper pieces) was randomly introduced into the moving sand layer, that quantity of trash elevated, passed over the cleaning bed, and collected in the basket was compared to that escaping through the cleaning unit. The cleaning efficiency (number of pieces collected/total number introduced) was used to evaluate the performance of the cleaning unit.

Six different test conditions using travel speeds ranging from 0.1 to 0.6 mph and three brush speeds were repeated three times each to evaluate the cleaning efficiencies. Resulting cleaning efficiencies ranged from 87 to 100 percent with an average of 95 per cent. Cleaning efficiency was not significantly affected by ground speed but was improved by increased brush speeds.

A portable power unit and a sand bunker were constructed and the cleaning unit was modified (as suggested by laboratory test results) for testing the machine under field conditions. Square discs were used in the cleaning bed (replacing circular discs used previously) to provide more aggressive cleaning and trash conveyance actions expected to be necessary under uneven terrain conditions. Qualitative evaluation of the cleaning unit performance revealed that trash could be removed effectively from the sand with this unit. Under relatively wet sand conditions, however, significant quantities of sand were carried with the trash to the trash holding basket.

A third generation cleaning unit, constructed to clean a 25-inch wide strip of sand, is shown in Figure 2. This unit contains four rows of rotating discs (D) spaced with 3/8-inch clearance between discs on each shaft and a rotating brush (B) composed of six bristled paddles. The discs, 2 1/4-inch-square pieces with corners rounded to a 2 3/4-inch diameter, are increased in size from those of the earlier cleaning unit models to provide a greater cleaning bed length and, therefore, allow more time for sand to fall back to the trap surface. Sharp edges occurring with square discs are avoided by the "rounded-square" shape. The tines (T), constructed from 1/4-inch diameter

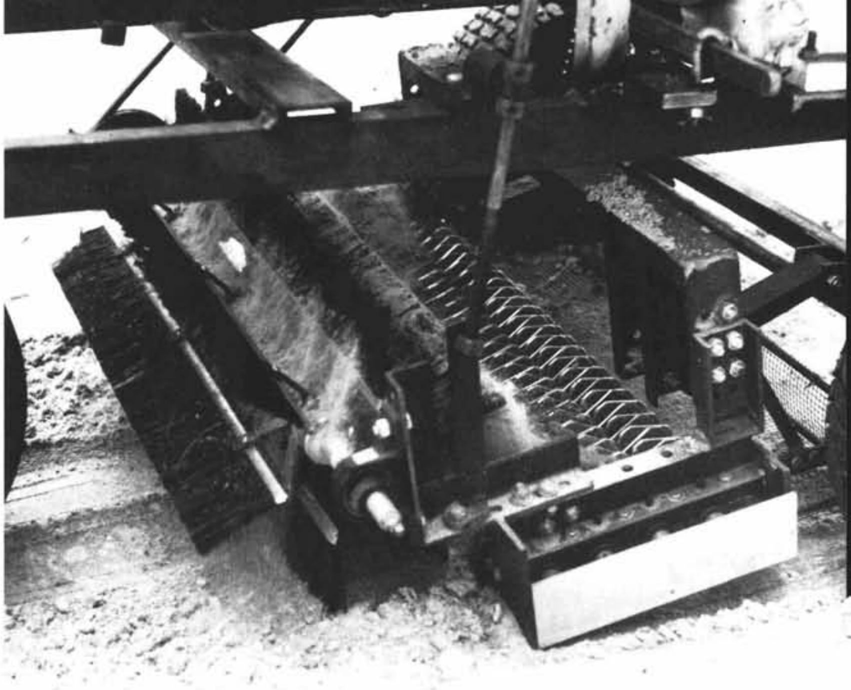


Figure 3. The cleaning unit operating in the sand bunker.

rods, are separated by 1/4-inch clearance to retain the trash but allow some sand to pass through. The 1/4-inch square holes in hardware cloth used in constructing the trash holding basket (H) allow retained sand to fall back to the sand trap surface.

The cleaning unit performance was evaluated by subjecting it to two 25-inch by 19-foot test strips in the bunker. One strip (for Test 1) had been hand raked five hours prior to the test, but the second (for Test 2) had not been altered since a 1-inch rain had fallen four days before. Fifty pieces of trash (wood and rock pieces approximately 1/4-inch in diameter) were scattered randomly over each test strip. The tines of the pick-up section were set to penetrate approximately 3/4-inch below the sand surface in both tests. Figure 3 shows the cleaning unit during the performance tests.

In each test the cleaning efficiency was evaluated by the ratio of the number of trash pieces collected to the total number that were within the cleaning width of the machine. Because a noticeable amount of trash was missed in Test 1, a second pass was made over that test strip in pursuit of a greater cleaning efficiency. The test results are summarized in Table 1.

Performance of the cleaning unit varied between 74 and 93 per cent efficient for the two tests. The pre-loosened and drier sand conditions of Test 1 resulted in greatest return of both sand and trash to the sand trap surface. The compacted sand surface of Test 2 encouraged mass movement of the sand-trash mixture and resulted in increased amounts of both sand and trash at the holding basket. Improved performance of the cleaning unit probably would result as greater experience with the unit is gained and better control is utilized to offset the effects of sand moisture and compaction on the cleaning unit performance.

The cleaning principle reported here does separate trash from sand as desired. As experimentation continues to determine optimum design and operating conditions for the unit, increased efficiencies and rates of cleaning can be expected. Development may be only a stone's throw from a cleaning unit that can be attached to available power units and can aid in overcoming trash problems in the sand bunker.

Table 1. Performance of the Cleaning Unit

	Number Collected	Number Not Within Reach	Cleaning Efficiency Ratio	Percentage
Test 1				
1 pass	34	4	34/46	74
2 passes	41	0	41/50	82
Test 2	43	4	43/46	93

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