MATERIALS AND METHODS

Three types of samples were taken from each of two greens on each of eight golf courses. The greenkeeper on each course was asked to point out the green on his course that could be maintained in good condition with the least amount of attention. The green so chosen will hereafter be referred to as the "best" green. Likewise, the greenkeeper was asked to point out the most troublesome green on his course, and that green will be referred to as the "poorest" green.

All three types of samples were obtained from two locations on each green. Samples were taken at intervals from September 26, 1949 to November 10, 1949. The following golf courses were sampled:

- Coffin Golf Course, Indianapolis, Indiana
- Edgewater Golf Club, Chicago, Illinois
- Ft. Wayne Country Club, Ft. Wayne, Indiana
- Foster Park Golf Course, Ft. Wayne, Indiana
- Meridian Hills Country Club, Indianapolis, Indiana
- Orchard Ridge Country Club, Ft. Wayne, Indiana
- Tam O'Shanter Country Club, Chicago, Illinois
- Willow Brook Golf Club, Indianapolis, Indiana
Samples for Percolation, Moisture Content, and Root Development Studies

The sampler designed by Baugh (4) and shown in Figure 1 was used to take "undisturbed" soil cores from the golf greens. It consists of a hardened steel cylinder with a removable cutting edge, a split internal cylinder of aluminum tied together with a steel ring at each end, and a steel plate and key that hold the internal cylinder in place when driving the sampler into the soil. The soil core taken by the sampler is 3 inches in diameter and 8 7/16 inches long.

Two such samplers were used for sampling the golf greens. They were driven down about 3 to 4 inches apart with the turf intact using a tripod and pounding device as shown in Figure 1. The cylinders were then dug out in the process of taking other types of samples that will be described later. One of the resulting soil cores was used for percolation studies, the other for root studies.

Upon removing the sampling cylinders from the soil, the key and plate were removed and the internal cylinder containing the soil core was pushed out. The lower end of the soil core was trimmed flush with the internal cylinder with a sharp knife. The internal cylinder, still containing the soil core, was laid on a flat board and the steel ring removed from each end. The cylinder was opened and the soil core exposed. The core that was to be used for
The soil sampler broken down (top) and in use (bottom), showing the tripod and pounder for driving it into the soil.
percolation studies was immediately coated with paraffin (Figure 2). The paraffin served as a support to hold the core intact while transporting it to the laboratory.

In the laboratory, the top of the soil core to be used for percolation studies was fitted with a celluloid band, and more paraffin was added with a brush until an unbroken coating of paraffin covered the sides of the soil core. The core was then wrapped with 2 inch gauze and more paraffin added to the gauze. The successive steps in coating the core after it was brought to the laboratory are shown in Figure 2. The result was a soil core, still undisturbed, with a water-tight and rigid coating.

Individual tension apparatus (Figure 3) were set up to receive the soil cores. The apparatus consisted of Coors No. 2 A Buchner funnels held in a specially constructed rack and fitted with glass T's and tubes leading to a water reservoir above and a constant-level device below. The tube leading down to the constant-level device is transparent so that a break in the water column may be seen. The Buchner funnel and all the connecting tubes are filled with water. Considerable difficulty was encountered in trying to get a continuous water column from the Buchner funnel to the constant-level device of the tension apparatus. With ordinary methods of filling, air was trapped under the perforated bottom of the funnel.

The problem was solved by the following procedure:
Fig. 2. Coating a soil core with paraffin in the field (top) and steps in preparing cores for the tension apparatus (bottom).
Fig. 3. The tension apparatus (top) and soil cores in place (bottom).
The Buchner funnel with a rubber connecting tube was inserted bottom up into a 12 quart bucket of water. The glass "T" with tubes and fittings leading to the water reservoir and constant-level device was also placed into the water. The glass "T" was then connected to the Buchner funnel, the connection made under water. The tubes were clamped and the fitting to the constant-level device put in place. The container (previously filled with water) was inverted to remove air bubbles below the clamp that got there when the fitting was removed from the water. The funnel is now turned upright, taking care that the perforated plate remains under water until the funnel is upright. The funnel, filled with water, is placed into the rack and held in place with a strong rubber band. The fitting for the water reservoir with tube attached is fitted into the reservoir (previously filled with water). The container is inverted to remove air bubbles above the clamp. The apparatus should now be filled with water and free of air bubbles.

With the tube leading to the reservoir clamped, the clamp on the tube leading to the constant-level device is open so that water runs out below. While the water is running out, two previously wet disks of photographic blotter paper are placed under water (one at a time) and pressed down against the perforated plate in the bottom of the funnel. If proper contact between the funnel and the blotter paper is made, the blotter paper will hold the
tension when the excess water is pulled out of the funnel. The height of the funnel is adjusted so that the top of the soil core will be under 75 cm. of water tension.

The soil core, prepared as previously described, is placed in the Buchner funnel with the soil at the bottom of the core in direct contact with the filter paper under tension (Figure 3). Paraffin just warm enough to pour and spread, is poured in the funnel around the core. The paraffin does not penetrate the wet blotter paper. When the first paraffin has hardened, hot paraffin is poured on top of the first to make a water-tight seal between the wall of the funnel and the coated soil core. When the second paraffin has cooled, the clamp on the tube to the reservoir is opened so that water drips out below. The clamp is regulated so that about 10 drops per minute are delivered. The clamp on the tube to the constant-level device is closed so that the water from the reservoir slowly wets the soil core. The top of the core is covered with a petri dish to reduce evaporation.

When the soil becomes saturated and free water stands over the turf and in the celluloid band on top, it is ready for the determination of percolation rate. The clamp on the tube to the constant-level device is opened and the clamp on the reservoir tube is closed. After a few minutes the percolation rate becomes steady and the rate of flow is measured. Water is added from the top to maintain an
approximately uniform head of water.

After the measurement of percolation is completed, another measurement is made with the soil core still on the tension apparatus. The water continues to percolate and as the free water disappears from the top of the core, the water is caught below for measurement. The quantity of water removed from the core from saturation to an equilibrium under the tension is measured. Evaporation was not taken into account, but the results are comparable. The water removed measures the effective pore space larger than a minimum size.

The soil core is then removed from the Buchner funnel by softening the paraffin with heat. The gauze is unwrapped and the celluloid band is removed. The core is sliced horizontally starting from the bottom and sections taken for the determination of moisture content. Care was taken to slice in and around layers that were previously noted. Each slice is broken in half and duplicate determinations of moisture content are made.

The soil core taken for root studies was sectioned horizontally, usually into three sections where layers were noted or natural breaks occurred. The sections were soaked and the roots washed out over a 20 mesh copper screen. The oven-dry weight of grass roots in each section was determined. The top 3 cm. of the core was removed because active roots could not be separated from the mat of dead and living plant material.
Samples for Pore Space, Volume Weight, and Particle Size Studies

After driving down the samplers described previously, an area of about one square foot of sod adjacent to the samplers was cut and removed to a depth of about 1 1/4 inches. Samples were taken in seamless tin cans, 3 inches in diameter and 2 inches deep, essentially as described by Lutz (20). The soil under the sod was smoothed with a modified pancake turner. A sampling can whose exact weight and volume had been determined previously, was pushed into the soil and the soil cut from around the can without disturbing the can. A knife sharpened on both edges was used to cut under the can and remove it without disturbing the soil in it. The soil was trimmed flush with the can and covered with a lid. The soil under the place where the first can was cut out is smoothed and another can inserted. About 1/2 inch of soil between the samples was lost in the process of cutting out the first can and smoothing the soil for the next sample. Four samples, one under the other, were taken in this manner at each area sampled. The approximate depth of the samples from the surface is as follows:

1. 1 1/4 to 3 1/4 inches
2. 3 3/4 to 5 3/4 inches
3. 6 1/4 to 8 1/4 inches
4. 8 3/4 to 10 3/4 inches.

The samples were taken to the laboratory, weighed, and
the lid removed. They were then placed with the open end up on a copper screen in a large photographic tray. Water was added to the tray until it came about 1/4 inch up on the cans. The water was allowed to enter a small hole (about 1/16 inch) in the bottom of the can and saturate the soil inside. After 12 hours, or longer if the samples were not yet wet on top, more water was added to the tray until the water was 1/8 to 1/4 inch from the top of the cans. After 12 more hours, water was added until the samples were completely covered. They were soaked in this condition for 12 hours. At the end of the 12 hour period, the samples were removed from the water, the same lids that were removed earlier placed on the bottom of the cans, and the weights taken immediately. The samples were then placed on a tension table under 50 cm. of water tension similar to that described by Leamer and Shaw (19). At first they were in an upright position, but when the excess water had drained off, the samples were inverted so that the open soil surface was in contact with the photographic blotter paper. After being under 50 cm. of tension for 36 hours, weights were again taken and the tension increased to 100 cm. The samples stayed on the tension table another 36 hours and weights were taken again. They were dried in an oven at 105°C for 48 hours and the dry weights determined. By using all the weights, initial moisture content, large pore space (that cleared by 50 cm. tension), medium pore space
(the difference in that cleared at 50 cm. and 100 cm. tension), small pore space (that not cleared by 100 cm. tension), and volume weight were calculated. Any pores that were not filled with water during the saturating procedure (blocked pores) were ignored.

The dry soil was removed from the sample cans, crushed, and passed through a 2 mm. sieve. The material not passing the sieve was washed, dried, and weighed as gravel. The material passing the 2 mm. sieve was used for mechanical analysis by Bouyoucos' (9) hydrometer method. The organic matter in a 50 gram sample was first oxidized with hydrogen peroxide, essentially as described by Robinson (26), except that larger samples were used. Hydrogen peroxide was added until no further reaction was obtained. The loss in weight was used to calculate the percent organic matter. The organic matter free soil was used for mechanical analysis. The following separates were obtained: clay - less than 0.002 mm., silt - 0.02 to 0.002 mm., sand - 0.02 to 2.0 mm., and coarse sand - 0.25 to 2.0 mm. (by wet sieving through 60 mesh copper screen).

Samples for pH, Readily Soluble Phosphorus
and Exchangeable Potassium Studies

In the process of digging out the samples described previously, two samples were taken for chemical studies. One sample was taken from about 1 to 4 inches from the
surface and the other 4 to 8 inches from the surface. The samples were air-dried and stored for analysis.

The pH, readily soluble phosphorus, and exchangeable potassium were determined on the soil after passing it through a 2mm. sieve. The pH of duplicate samples was determined using the method outlined by Peech et al. (24).

The modified Truog method outlined by Peech et al. (24) was used to determine readily soluble phosphorus in the samples. Color intensities were read on an Evelyn colorimeter.

Fifty gram samples of air-dry 2 mm.-sieved soil were extracted with 1 N ammonium acetate solution adjusted to a pH of 7.0. The potassium in the extract was measured with a Perkin-Elmer flame photometer, Model No. 52-A, using the modified internal standard procedure advocated by Rouse (27).