Electricity *Warms Soils* for Sport Turf

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SOIL WARMING is now eligible for acceptance as a part of turf management programs. Most perennial turf grasses, including Kentucky bluegrass, tend to grow continuously except when limited by climatic extremes. Rootzone heating of turfgrass plants can keep the soil from freezing, promote root growth, keep the turf greener, and aid in melting snow. Such improved turf conditions would reduce player injury and increase the precision of games. Also, numerous outdoor activities, such as horseracing and golf, could be extended beyond the present active seasons.

Escritt's early work at the Sports Turf Institute in England has led to several electric heating installations there. Everton Football Club was the first to install electric soil warmers in their ground at Goodison Park. Electric, off-peak (low rate) pitch warming is built into the Arsenal ground at Highbury. Edinburgh, Scotland's Murrayfield rugby football grounds were equipped with electric heating in 1959. At least one stadium in Sweden has electric, and another has water soil warmers.

Turf Heat Tests Started Feb. 1962 at Purdue

Preliminary soil warming studies at Purdue University, Lafayette, Indiana, started on a 20- by 50-foot plot in Feb-

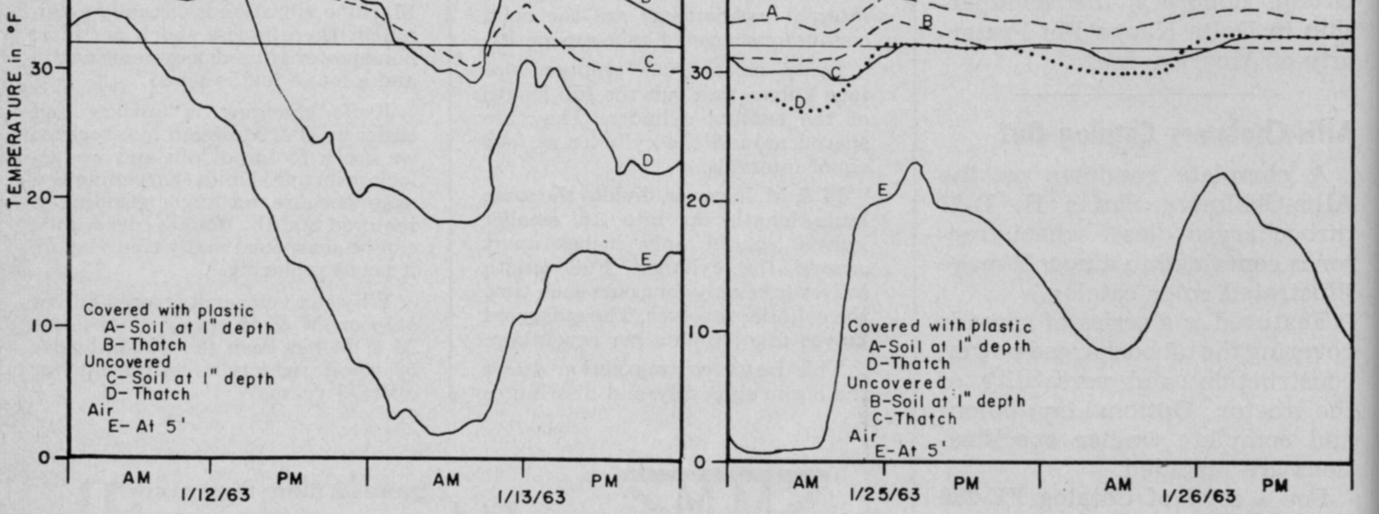

Fig. 1. Temperature fluctuations recorded in thatch, soil 1 inch deep, and in air over electric soil-heating cables that dissipated 1.2 watts per square foot. **Right** graph shows temperatures recorded when there was a 1- to 3-inch snow cover. **Left** graph represents temperature changes recorded when plot was not snow covered.

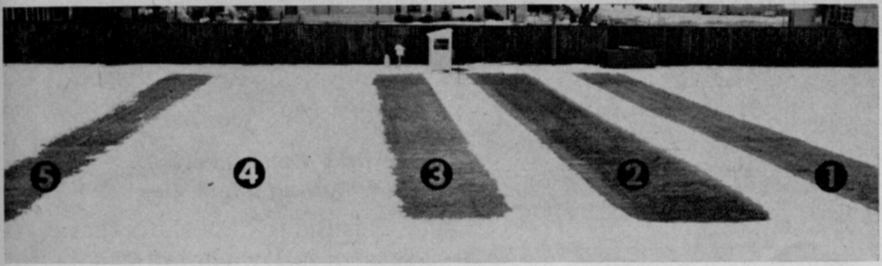

Fig. 2. Snow melting pattern on five electric heated turf plots, installed August 1963, shows that during the 1963-64 winter snow remained on Plot 4. Cables in Plot 4 were spaced 15 inches apart, at least twice as far apart as in the other plots. See Table 1.

ruary 1962. Aluminum and copper heating cables insulated with poly-vinyl chloride were tested. Six different cable spacings and clear plastic sheet covering were also evaluated. Constant soil heating produced soil temperatures of 65°F. Within a 10-day period in early March, excessive bluegrass growth was apparent while unwarmed turf remained dormant on frozen soil.

An improved experiment was installed in October 1962. Soil was removed from an area 20 by 60 feet, and cables were placed at 4-, 6-, and 8-inch depths with spacings, 6, 12, 18, and 24 inches apart. Different spacing and depths established wattage densities that ranged from 0.8 to 10 watts per square foot. Soil was replaced and firmed over the cables; soil thermostats were buried at 1-inch depths; power cables were laid; then bluegrass sod was placed over the entire area. Energy consumption, soil moisture content, rainfall, relative humidity, and snow-melting data were recorded. To sense abrupt changes in weather, air thermostats were wired in parallel with soil thermostats allowing either to operate the cables.

Plastic Covers Retain Sun's Heat

Plastic covers .004 inch thick utilized solar radiation and warmed the turf by reducing heat loss (Fig. 1). Covers provided both an insulating air layer over the turf and served as a barrier to reduce wind action. Benefits given by plastic covers were:

1. Grass blades desiccated less in cold, dry winds and remained essentially a normal green at low temperatures.
2. Covering reduced energy required on lower wattage densities. Cables spaced up to two feet and wattage densities as low as 0.8 watt per square foot kept the soil thawed throughout the winter under plastic.
3. Sod roots developed early and were more uniform under plastic covering.
4. Turf, under cover, grows more readily as any warm period arrives, responding much better to sunny weather and rising air temperatures than uncovered turf.

Disadvantages of plastic covers are:

1. Covers prohibit casual use and decreases aesthetic value of turf areas.
2. Hot, sunny periods may force unwanted, excessive growth.
3. Risk of cold damage to tender foliage is increased when the plastic must be removed in early spring. Extra care is needed when covers are removed and replaced in variable spring weather.
4. Disease (leafspot) incubation on leaves may be favored by unusually high humidity and warmth under covers.

Safe Depths Recommended For Heat Cables

Little difference was found in soil or turf conditions above cables 4, 6, or 8 inches deep. For better safety and normal protection from mechanical damage, depths of 6 to 8 inches are suggested.

Rootzones Extend Rapidly When Heated

Soil warming offers valuable rootzone benefits. Freshly cut sod placed in nonwarmed areas on November 10, 1962, developed almost no roots before winter. However, on heated soil new root extension was 3 to 5 inches by December 31. By April 1963, new white, active roots of the heated sod were 9 inches deep, but only 5 inches deep in unwarmed sod. Such root extension provided greater sources of nutrients and assured minimum damage from drouth or active sports. Top growth continued well into late fall and again in early spring, 1963.

Temperatures only sufficient enough to keep rootzones thawed and porous produced obvious top growth in early March, three weeks ahead of unwarmed turf. Higher heat inputs that maintained soil temperatures above 45°F, at 1-inch depths favored top growth throughout the winter. Wattage densities of 10 watts per square foot kept the turf thawed at all times. Soil temperatures above 55°F forced some turf growth, even during extended, severely cold weather. However, sharp drops to low temperatures caused some leaf tip damage to rapidly growing grass.

Interestingly, warmed turf areas produced seed heads six weeks earlier than unwarmed areas, indicating more crown growth through the winter period. All uncovered turf areas looked normal in density and uniformity after heating was stopped. Additional root development and continued tiller and rhizome growth indicated improved playability for warmed turf areas. Important to games use, the warmed areas were

Editor's Note: Practicality of turf heaters was shown last winter when they successfully kept snow off and turf green at a golf course practice green in South Bend, Ind.

never muddy, superwet, or slick from frost action.

Melted Snow Layer Easy To Remove

In plots with heat applied at 10 watts per square foot, snow melted rapidly when air temperatures were above 15°F. At colder air temperatures, melting was slower, although soil remained thawed and turf remained green. In cold weather, snow melting from underneath left an air pocket with a crust of snow or ice laced on the grass-blade tips. Heavy snow can be removed quickly by machinery for sport field, turf clearance.

Table 1. Design and time of actual operation of plots in 1963-64 tests.

Plot	Cable Spacing	Watts per sq. ft.	Max. time plots could operate per day	Max. time plots operated per season
	inches	watts	hours	%
1	1.5	4.5	24	74
2	7.5	9.0	24	71
3	7.5	9.0	7	95
4	15.0	4.5	7	97
5	7.5	2.5	24	99

Cables Buried by Knife and Guide Tube

Five plots, 10 by 120 feet, each separated by a 10-foot-wide unheated strip, were installed in the Purdue varsity football practice field (Fig. 2) in August 1963. Poly-vinyl chloride insulated, nylon-jacketed, electric heating cables were laid six inches deep in existing sod. Cables were laid by using a rolling coulter followed by a vertical knife and guide tube for wire burying; all were fastened to the toolbar of a tractor. Cables were spaced either 7½ or 15 inches apart and provided 2.5, 4.5, or 9 watts per square foot. Soil thermostats, air thermostats, and timeclock switches were wired in the control circuits. Turf was smooth enough for football practice immediately after the cable was installed and rolled.

Air Temperature Turns Heat On, Soil Temperature Turns Heat Off

Soil is warmed to prevent it from cooling below root growth temperatures. Air temperature is the best indicator of when heat should be applied. Temperatures in the soil indicated the heat reserve present and soil thermostats were used as maximum temperature limit-switches to prevent overheating the soil.

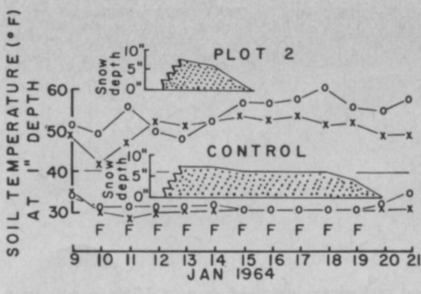

Fig. 3. Temperature changes during a period with snow cover in January 1964. Lines labelled "X" are readings taken at 8 A.M.; lines marked "O" are readings taken at 4 P.M. "F" indicates that the turf was frozen at 8 A.M. Dotted areas in the small graphs show the depth of snow cover and its removal.

Preset timeclocks facilitated using heaters during off-peak (low rate) periods during early morning hours. Plots 1 and 2 were heated any time the air temperature was less than 40°F, or when soil temperature, 1-inch deep, was less than 45°F, regardless of air temperature. Conversely, heat was not applied when the 1-inch soil temperature was above 60°F, regardless of air temperature. The first test season lasted from November 6, 1963, through April 6, 1964, a period of 152 days (Data are given in Tables 1, 2, 3, and 4).

Table 2. Average soil temperature one inch deep at 8 A.M. (F°), 1963-1964.

Plot	Dec.	Jan.	Feb.	Mar.
1	43	40	41	44
2	54	49	52	54
3	42	40	40	46
4	37	35	36	41
5	40	38	38	44
Control	34	32	32	37

Table 3. Number of days turf medium was frozen at 8 A.M., Jan. 1 to March 31, 1964 (91 days).

Plot	Jan.	Feb.	Mar.	Total
1	4	0	0	4
2	0	0	0	0
3	8	1	0	9
4	10	7	2	19
5	11	1	0	12
Control	24	19	7	50

The second test season lasted from October 9, 1964 to April 12, 1965, a 186-day period (See Fig. 3).

Heaters Ready For Turf Management Use

Results to date show that cold-season soil warming can be included in modern turf management programs. It can be used as a tool to improve playing conditions by thawing soil, melting snow, and maintaining more vigorous turf.

Four seasons of research have been completed at Purdue, and new plots are being installed. Demonstration plots are also located at St. Paul, Minnesota; St. Louis, Missouri; Washington, D. C.; and South Bend, Indiana. Some work has been done in Arizona and Texas under bermudagrass and st. augustinegrass. Turf heater installation in several stadiums where both football and baseball are played is now being considered. However, the first one is yet to be installed.

Obviously, the area and use for each turf plot or field, location related to climatic conditions, availability of power, and the grass species used will determine the design of the heating system. An index on which installation requirements may be based is day-degrees (sum of daily average temperature below 65°F for one season). St. Louis, Missouri has approximately 4600; Indianapolis, Indiana has 5500, and St. Paul, Minnesota has 8000.

Specifications for controls and cables, giving 5 watts per square foot, off peak, have been prepared for the new Busch Stadium in St. Louis. Bids are being taken now for installation before sod is laid, and the stadium will be finished by May 1966.

Table 4. Temperatures (F°) at 8 A.M. on January 29, 1964

Soil Depth	Plot 2	Plot 5	Control
Thatch	37	31	29
1 inch	46	34	31
6 inch	61	40	35
1 foot	63	44	37
2 feet	61	45	40
3 feet	60	50	42

Shaded air temperature was 18 F°