A LIGHTWEIGHT HAND CORING AUGER

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Abstract

Extensive use of glass epoxy composites has allowed the design of an auger capable of drilling to 30 m without the use of a tripod, or to 50 m with a tripod to assist in raising the drill string. Approximate weight of a 10-m drill is 10 kg. Since most of the drill is already made of plastics, applications for making a "clean" drill are also discussed. Further refinements using solar voltaics and more exotic materials to ease the drilling burden are discussed. This drill has been tested in Antarctica, Greenland and the Peruvian Andes to near its proposed depth limit.

Introduction

The PICO lightweight hand coring auger is designed for ice core drilling in high-alpine, remote locations where it is difficult to transport and use heavier augers and electromechanical drills. The PICO auger has proved itself as a viable alternative to the SIPRE auger in most coring applications to depths of less than 50 m.

The PICO hand auger is built entirely out of materials with high specific strengths. The core barrel, extensions, T-handle and tripod are made of commercially available fiberglass composite pipe (Figure 1). Fittings, adaptors and cutting heads are machined from aluminum. Shipping and carrying containers are canvas duffle bags. The few tools necessary to service and maintain the auger are available from most hardware stores.

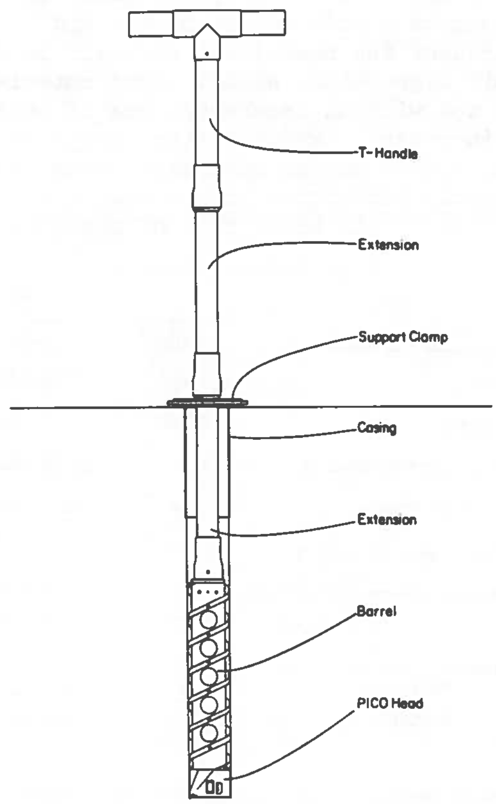

Figure 1. Lightweight hand auger with casing.

Drill Description

The use of composite materials, with their favorable specific strength, has increased hand augering depth capability to the 50-m range. Traditional SIPRE auger cutting heads and bits have been redesigned to include core dogs which enhance core-catching capability. This drill system has been used with an electric motor and solar voltaics as a power source to decrease drilling time while avoiding contamination of the snow surface otherwise associated with gasoline-powered generators.

The concept of using glass-reinforced composites in drills and extensions is neither new nor unique in glaciological applications. However, the unique properties of composite materials and current mass production practices has made it desirable from structural and economical viewpoints to use these materials in drilling applications.

Table 1 makes it readily apparent that composites exhibit superior specific strengths and specific modulus where compared with aluminum or steel. Kevlar and graphite are nearly ten times as strong on a unit weight basis, and represent the near ideal solution to a truly lightweight drill. Both materials are not without drawbacks, one of which is increased costs. Custom layups of composites require special tooling and assembly techniques, resulting in a cost of five to six times that of standard water pipe of E-glass or S-glass and epoxy. A more detailed description of the auger's components is provided below.

The core barrel, available in either 1- or 2-m lengths, is a piece of 7.5 cm diameter composite pipe wrapped with two ultrahigh molecular weight polyethylene spirals cut from sewer pipe and riveted to the barrel. An aluminum adaptor, held in place by quick-release pins, is used to connect the core barrel to the extensions.

The extensions are 5-cm diameter composite pipes which are cut to either 1- or 2-m lengths, and with weigh 1 kg and 1.5 kg per extension, respectively. Since it was recognized that nearly all the strength benefits of oomposites are lost when the glass fibers are cut, a design problem was encountered in determining the method to be used to join the extensions. Screw threads were decided upon as being the least expensive alternative since other attachment methods involved more intricate mechanisms and heavier components. The screw threads are modified ACME threads which are used commercially to join lengths of composite water pipe. The strength of the joints and pipe used in the lightweight auger are thus more than

Material	Density gm/cm^3	Modulus of Elasticity MPa	Ultimate Tensile Strength MPa	Specific Modulus 10^8cm	Specific Tensile Strength 10^6cm
Steel	7.85 {1}	206,800 {1}	448 {1}	2.7	3.2*
Aluminum	2.78 {1}	73,100 {1}	310 {1}	2.7	1.1
Glass Epoxy Composite	1.84 {1}	39,300 {2}	1100 {2}	2.6	5.8
Kevlar 49 Fibers	1.44 {3}	131,000 {3}	3447 {3}	9.1	24.0
Kevlar-Epoxy Composite	1.38 {3}	75,800 {3}	1380 {3}	5.5	10.0
Graphite Fibers Fortafil 3	1.71 {2}	206,800 {2}	2482 {2}	17.5	14.5
Fortafil 5	1.77	331,000	2758	18.7	15.6
Graphite-Epoxy Composite Fortafil 3	1.52 {2}	117,000 {2}	1034 {2}	7.7	6.8
Fortafil 5	1.53	186,200	965	12.2	6.3

Specific Modulus = Modulus of Elasticity ÷ Density

Specific Tensile Strength = Ultimate Tensile Strength ÷ Density

*Strands of wire cable.

{1} Baumeister, T. et al., 1978.

{2} DuPont, Wilmington, Delaware.

{3} Great Lakes Carbon Company, New York, 1980.

Table 1. Comparison of material properties.

adequate for this application. One advantage of using screw threads is that nothing sticks out beyond the O.D. of the extensions, such as quick-release pins would, thereby eliminating the problem of chips being scraped off the hole wall. As a result, the core length capability is not decreased due to the barrel filling up with the chips from the hole wall. The extensions can be easily detached in 1-12 m increments (Figure 2).

Tests in Greenland during the past two seasons have demonstrated the capabilities of this drill. By using the 2-m core barrel, cores ranging between 1.2 m and .8 m are retrieved each run. As a result, 20 m holes can be drilled in half a day, 30 m in one day, and 40 m in less than two days. Depths beyond 40 m require the use of a tripod and a strong desire to go deeper.

A new cutting head has been designed to incorporate both a tapered annulus and core dogs to insure positive catching of the core after each run. Additionally, the leading angle of the cutters has been made more shallow (45°) for easier cutting. Adjustment screws are necessary to control the rate of penetration and to avoid jamming the drill (Figure 3). While the current heads are made of aluminum and steel, alternative materials are available to avoid contamination of the core. A Delron or Nylon head with tungsten carbide cutters is one example.

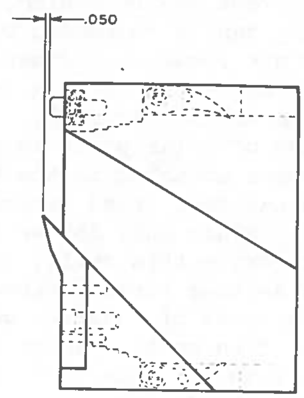

Figure 3. Cutting head showing adjustment screws.

Figure 2. PICO driller with 9 m of extensions.

Accessories

The use of a tripod to assist in lifting the drill string increases the depth capability of this system to 50 m. A block and tackle is used to multiply the lifting force by four. By using a casing around the top of the hole and clips which rest on the casing, the drill string can be suspended while extensions are removed, further relieving the burden of raising and lowering the drill (Figure 4).

The use of solar power to drive an electric motor attached to the topmost extensions has been tried successfully (Figure 5). Since only 250 watts are required to drive this drill, the motor package is neither large nor heavy. Penetration rates of 1 cm/sec were achieved in firn at 40 m depth on a sunny day, with the rate being reduced by half on a cloudy day.

The weight of this drill in its current state is as low as .75 kg/m per extension, added to 3 kg for the drill barrel and head.

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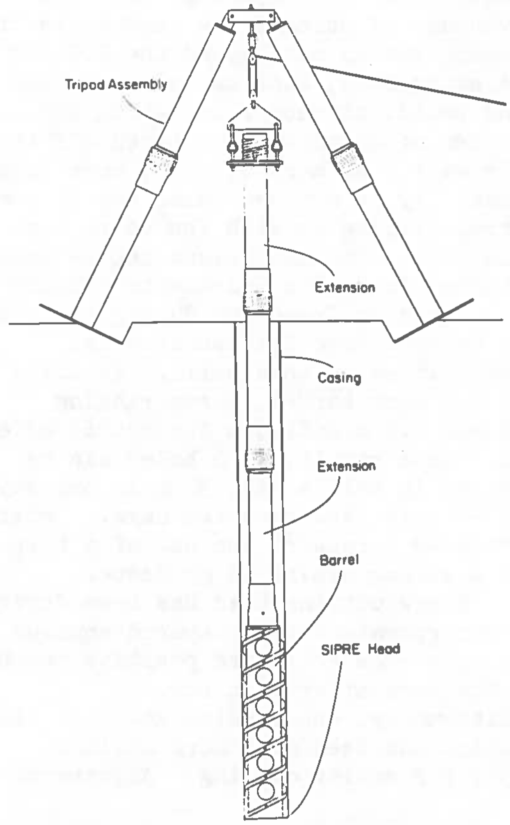

Figure 4. Lightweight auger with tripod assembly.

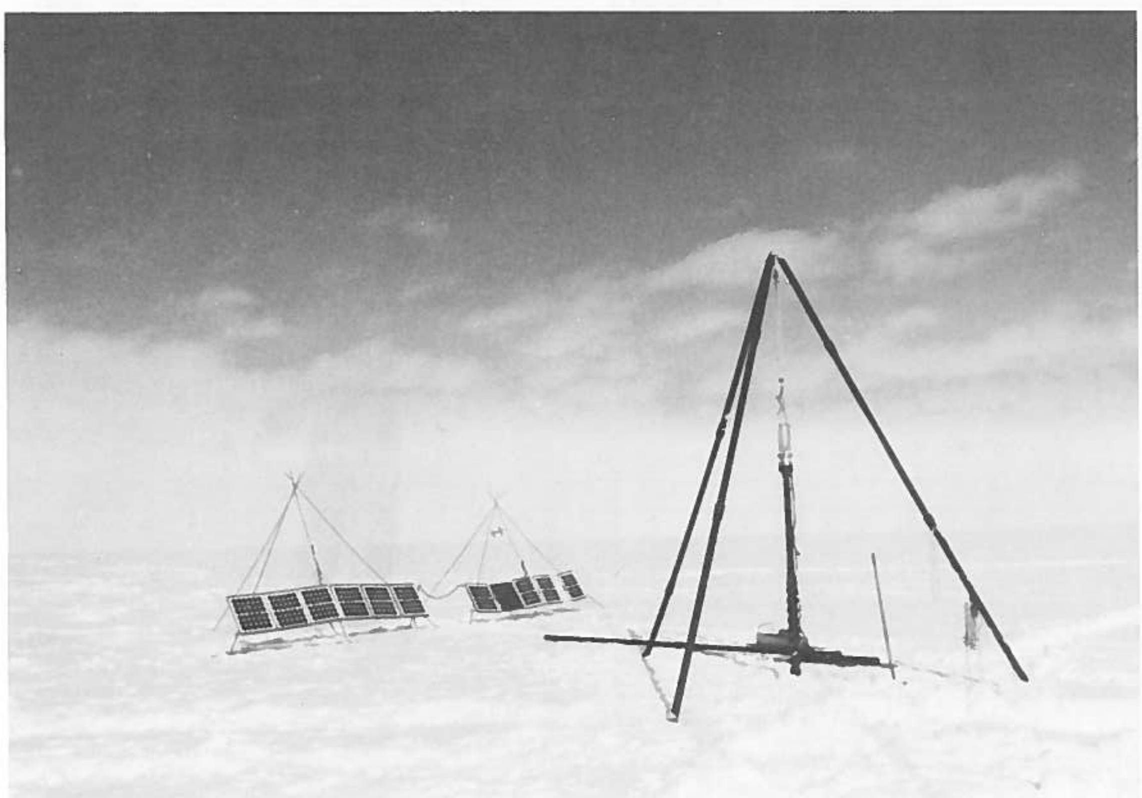

Figure 5. Lightweight auger with solar-generated power.

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