STUDIES IN GLACIER PHYSICS ON THE PENNY ICE CAP, BAFFIN ISLAND, 1953

Part II: PORTABLE ICE-BORING EQUIPMENT

By W. H. Ward

Abstract. The construction and use of some portable ice-boring equipment are described. The total weight of equipment for boring to a depth of 20 m. is about 36 kg. The weight increases by 1 kg. for each extra metre of depth.

Résumé. On a décrit la construction et l'usage des appareils portatifs pour sonder la glace. Le poids total des appareils pour un sondage de 20 m est 36 kg environ. Le poids augmente d'un kilogramme pour chaque metre en profondeur.

The weight of recoverable equipment flown to the ice cap had to be kept to a minimum in anticipation of a long sledge trip and an unknown amount of back-packing during evacuation. Anticipations were largely satisfied. In any extensive field-work, and especially in difficult terrain, light equipment is an asset; on the glaciers it is most convenient if it can be carried by a skier, or on a sledge towed by a skier. In such conditions a maximum weight of about 80 lb. for boring equipment seemed to be a reasonable target.

Broadly speaking the boring equipment consists of two parts, the lifting rig and the string of rods that operate the coring tool.

The lifting rig consists basically of a light pole 20 ft. (6 m.) long with a single pulley at the top. It is anchored to the ground by guy ropes. The main purpose of the rig is not so much for lifting, but rather as a high-level resting post for the string of rods when the coring tool is raised. In the absence of such a post the operator finds it necessary to lower the rods horizontally to the ground when they become longer than about 20 ft., and beyond 30 ft. (9 m.) it even becomes difficult to lower them safely from the vertical to the horizontal position, particularly in strong wind. This difficulty can be overcome by uncoupling the rods in convenient lengths of about 15 ft., but this slows down the work unduly. It is possible to keep strings of rods up to 40 ft. long resting against the 20 ft. rig with their lower ends resting on the ground. A sketch of the rig with two strings of rods resting against it is shown in Fig. 1 (p. 435).

In this instance it was convenient to construct the rig pole from four 5 ft. lengths of standard aluminium scaffolding tube ($1\frac{1}{2}$ in. inside diameter B.S. pipe—38·1 mm.) with a short cross-piece of tube fixed at the top for rope fastenings. The tubes were joined by the usual scaffold couplings. The post is erected with a slight lean so that the rope coming from the pulley at the top hangs over the borehole, while the base of the post is out of the way to one side of the borehole.

At one site on Highway Glacier a large boulder (a good marker) lying on the surface served the purpose of the resting post. The boring was made a few feet from the vertical face of the boulder and the rods when raised leaned against it. It is wise with boulders of this size to examine the ice pedestal before selecting the position of the borehole, and to decide which way the boulder is going to slide off the pedestal; otherwise the borehole may become inaccessible. In the northern hemisphere large boulders tend to move southwards in the absence of local disturbances.

In firn snow which is easily dug, it may be convenient to bore from the bottom of a pit and to use its walls for supporting the boring rods. A substantial stake driven near the surface can support the lifting pulley. Alternatively, the lifting rig has been erected on the surface alongside the pit to give even greater height between the top of the post and the base of operations.

In 1946 at the Building Research Station the writer, with the help of the Northern Aluminium Co. Ltd., developed an aluminium alloy boring rod for deep soil exploration by hand. Shortly afterwards its use for boring on glaciers was recommended to Mr. G. Hattersley-Smith for work in British Grahamland, where it is understood to have proved satisfactory. In the meantime

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several modifications have been made to improve its serviceability and its use has extended. For hand boring a rod 3 ft. (1 m.) long seems to be the optimum incremental length, and it is convenient for bundling on a back-pack. The cross-section of the rods and their weight per unit length must enable the longest possible string of rods to be lifted from a horizontal position on the ground to the vertical without breaking. This demands a strong and light material, and aluminium alloy is the obvious choice. The torsional strength of the rods must be adequate and their coupling simple, rigid and quick in action. The construction of the boring rod is shown in Fig. 2 (p. 435). The extruded alloy tube has plugs riveted in each end, one plug has a female thread and a tommy-bar hole for unscrewing, the other plug has a male thread. The inside of the tube is watertight and the rod just sinks in water. It is important that the screw threads are smoothly cut in a screwing machine, with their axes in line with the tube axis. The shoulders formed at the screw joints are advantageous when lifting the rods vertically, particularly when they are glazed with ice. Silicone grease is the best lubricant for the threads and they never seized, even when watered, screwed up and subsequently frozen. If there is a risk of grit contaminating the threads, a small clearing groove should be milled across the male thread. A short length of soft rubber hose must be pushed over the exposed male threads to protect them when not in use, one of the rods in Fig. 3 (p. 415) is shown protected at the upper end.

The boring rods are rotated, and loaded axially if necessary, by a carpenters' brace. One with a throw of 10 in. (25 cm.) is satisfactory. Its chuck is removed and the split portion of male thread exposed is cut off. An aluminium alloy adaptor (see Fig. 2) is made to screw the brace to the upper male end of the string of rods. This adaptor has a tommy-bar hole.

The rotary steel coring tool (see Fig. 2) fitted to the lower end of the rods is similar to the design suggested earlier.[1] At its upper end is a mild steel adaptor which screws on to the rods and slides a short way inside the coring tube. The heads of two set screws engage in corresponding holes in the coring tube. The set screws are never mislaid, because they are screwed *inwards* to release the coring tube. The latter is made from a piece of drawn steel tube 20 in. long and is of the minimum diameter which will clear the rods ($1\frac{3}{4}$ in.—44·5 mm.). The saw teeth are cut and set by hand and are not hardened. In clean ice the teeth never wear, but if damaged or used in gritty ice they are easily sharpened with a fine file. The teeth need to be kept sharp. To provide space for the ice powder formed at the saw teeth the tube wall is perforated as much as possible. Numerous $\frac{7}{16}$ in. (11·1 mm.) diameter holes are bored and three spirals of slots are cut between some of the holes. The slots were cut with a small hacksaw, the blade of which could be passed through diametrically opposite holes. In dense ice three spirals of slots worked better than only one or two spirals, but even in dense firn one spiral is adequate. The tube must be kept bright and smooth. In Fig. 3 the brace is shown connected directly through the two adaptors to the coring tool ready to start boring. This coring tube has only one spiral of slots and alongside are three lengths of boring rod.

The coring tool works easily through all forms of snow and dense firn below the melting point. Even in firn with a density of 0·5 it would be advantageous at large depths to use a longer coring tube to reduce the frequency of raising the rods. Up to a density of 0·6 the cores are relatively undisturbed. Frequent ice layers up to about 4 in. (102 mm.) thick are no trouble, but in continuous ice with a density over about 0·8 the work is more laborious. There is an art in boring through continuous dense ice, which can only be mastered by practice. From the feel of the brace and the sound when boring it is possible to tell when the saw teeth are cutting into dense ice. As soon as cutting stops a short core will have become jammed in the coring tube and have sheared off from the intact ice below. The detached core is riding on the ice at the bottom of the hole and is preventing the teeth from further cutting. For a given set of conditions this happens after a certain number of turns of the brace. The string of rods now needs to be lifted a few inches and lowered fairly fast or dropped on to the bottom of the hole. The object of this is to loosen the ice powder jamming the core and to force the core upwards into the tube. A further short core can then be cut and the process repeated. With practice one learns how to bump the rods just before the core starts to jam, and the boring process becomes a continuous rotary motion with an occasional vertical movement of the rods.

When the coring tool is sufficiently full and has been raised to the surface, the series of short cores separated by thin layers of ice powder is easily released by tapping the side of the tube with the silver steel tommy bar, $\frac{3}{8}$ in. diameter by 12 in. long (9·5 × 305 mm.), that is used to unscrew the rods.

The density profile in the firn at Camp A1[2] was determined by placing all extracted material for roughly each 10 ft. (3 m.) of depth into separate cartons. Independent measurements of the weight per unit length of material extracted from cored holes in material of known density are used to estimate the average density of the material in each carton. The intact cores in each carton are then trimmed to right cylinders and their density measured separately. This work can only be done at low temperatures, and a deep pit is a convenient place.

A total of about 250 ft. (75 m.) of boring, mostly in dense ice, was carried out during the 1953 summer along the 40 km. course on the Penny Ice Cap. The total length of rod taken was 60 ft.

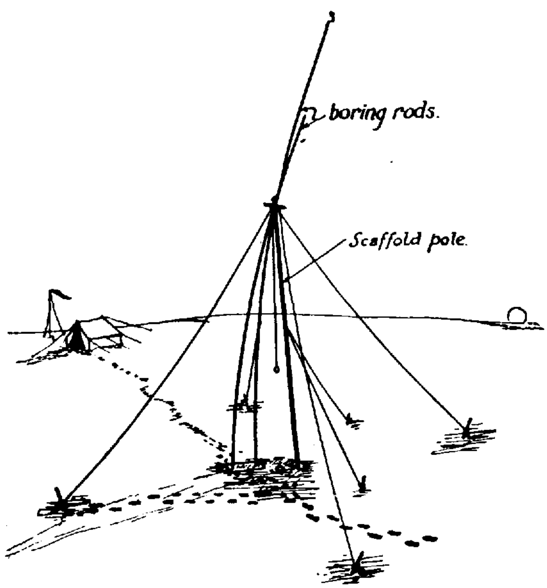

Fig. 1. Sketch of lifting rig with two strings of rods leaning against it

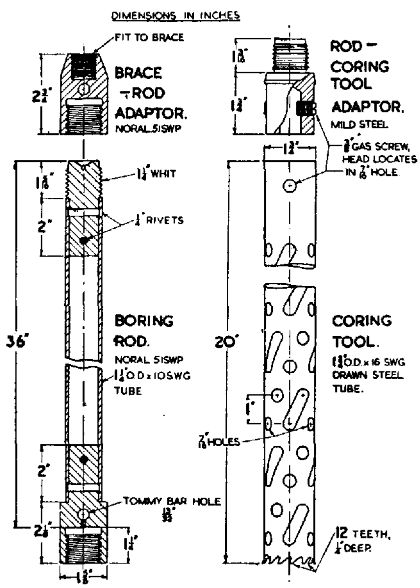

Fig. 2. Details of boring rod, coring tool and adaptors

(18 m.), that is 20 rods, and this was the depth of the deepest hole. The first 30 ft. was bored single-handed in about 2 hours, and the remainder completed with the assistance of Mr. Svenn Orvig in 3 more hours. Two more holes each 32 ft. deep were bored in continuous ice in about 2·5 hours single-handed. The ice temperature varied down to −14° C.

It is considered that it would be a reasonable proposition to bore to a depth of 150 ft. (45 m.) in dense ice by hand, using the above equipment and with two men. Beyond that depth, stronger lifting equipment would become necessary.

The weights of the various items of equipment are as follows :

1 Brace	1·6
20 Boring rods at 1·0 kg. each	45·0
1 Brace-rod adaptor	0·3
1 Rod-coring tool adaptor	1·3
1 Coring tool	1·3
1 Lifting rig complete	30·0
Total weight	80 lb. (36 kg.)

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2. Ward, W. H., *and* Baird, P. D. Studies of glacier physics on the Penny Ice Cap, Baffin Island, 1953: Part I—A description of the Penny Ice Cap, its accumulation and ablation. *Journal of Glaciology*, Vol. 2, No. 15, 1954, p. 342–55.

ICE SHELF TERMINOLOGY

The British Glaciological Society has received the following notice from the Antarctic Place-names Committee. It is understood that official publications in the British Commonwealth will now adopt this terminology.

As a result of discussions between the United Kingdom Government Departments concerned, representatives of the Governments of Australia and New Zealand, and the Royal Geographical Society, and taking into account views expressed by the United States Board on Geographic Names, it has been agreed that the following terminology shall be adopted for United Kingdom official use for describing those ice formations in the Antarctic to which the terms "ice barrier," "ice shelf," etc., have been variously applied:

1. (*a*) The general term describing any such formation shall be *Ice Shelf.*

(*b*) The place-name describing a particular feature of this kind shall be a compound which shall include the term *Ice Shelf*; *e.g.* "Larsen Ice Shelf."

2. (*a*) The general term describing the floating seaward-facing cliffs of an ice shelf shall be *Ice Front.*

(*b*) The place-name describing a particular ice front shall be a compound which shall include the term *Ice Front* together with the date of the appropriate survey; *e.g.* "Ross Ice Front (1911)."

3. In order to avoid confusion, the word "barrier" shall be excluded from modern usage, but the "Ross Ice Shelf" and the "Filchner Ice Shelf" may have marked under them, in brackets and in smaller lettering, the phrase "Formerly Ross Barrier," "Formerly Filchner Barrier."

4. There would be a danger of confusion if the term "shelf ice" were to continue to be used for the description of the material itself, and discussions are taking place between the Royal Geographical Society and the appropriate United States authorities to discover an alternative term to "shelf ice" for this genetic usage.

The following place-names in the Falkland Islands Dependencies are therefore officially accepted:

Filchner Ice Shelf; Larsen Ice Shelf; Wordie Ice Shelf.

The Australian and New Zealand Governments have notified their intention to adopt the same ruling for similar formations in the Australian Antarctic Territory and in the Ross Dependency respectively, *e.g.*

Shackleton Ice Shelf; Ross Ice Shelf, etc.

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