A SUBMERSIBLE, RECHARGEABLE, ELECTRIC DRILL

by W. H. Easton[1]

Abstract

A light weight, cordless, rechargeable, electric hand drill mounted in a submersible plastic case is linked by a shaft through the housing to an external bit extension. Tungsten carbide masonry bits or small diamond core drills can be attached to the end of the bit extension without opening the underwater housing. The assemblage has been used to set survey points used in measuring shoreline erosion and to take core samples for radiometric dating and for determining growth rates of corals by X-radiography. Other applications have been suggested.

Design

The prototype model (Figure 1) was designed to accommodate the smallest rechargeable drill in order to reduce weight and volume taken on flights to distant islands. A submersible housing was constructed of 3/8" and 1/2" acrylic plastic to fit two inter-changeable models of drills — the Craftsman Rechargeable 1/4" Model No. 135.111100, and Skilshop Model 1702 Type 1 Cordless 1/4" Reversing Drill. The assemblage weighs 3 kg (6.7 lbs) and will float. General information and materials used in the construction of plastic housings can be obtained from hobby shops, plastics salesrooms, and Toggweiler (1970). Prefabricated control glands with O-rings, and levers, shafts, and stud retainers with studs and nylon wing nuts for closing housings are available from some dive shops and Toggweiler.

A few special requirements must be met in designing the apparatus. The acrylic plate in front of the drill chuck must be at a right angle to the axis of the chuck, because the control gland containing an O-ring through which the shaft of the bit extension passes also must be aligned perfectly with the axis of the chuck after the gland has been cemented to the front plate of the housing. The rear of the drill case must just touch the inner surface of the rear plate of the housing so that a thrust applied to the housing by the operator will

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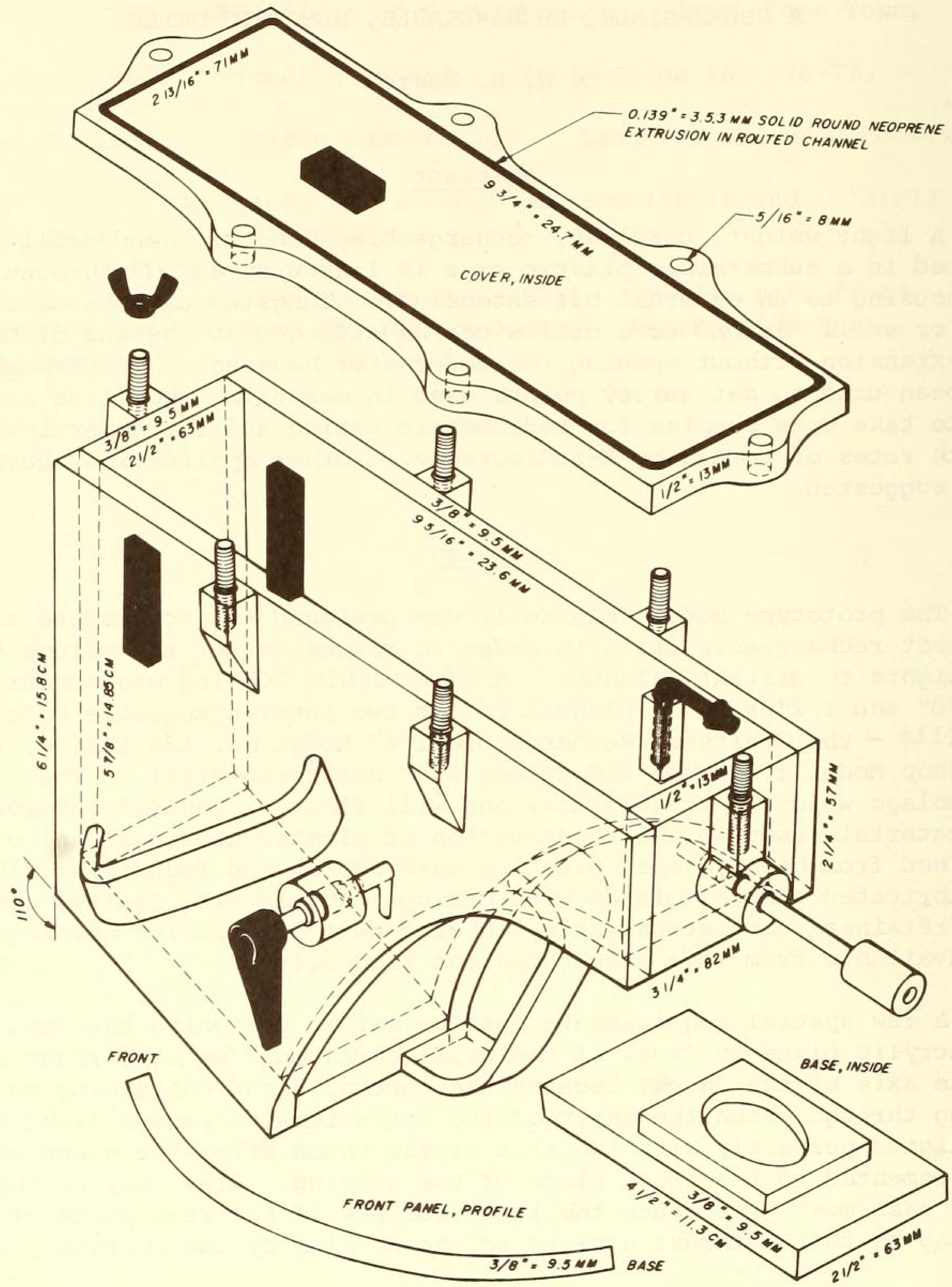

Figure 1. Submersible housing with bit extension attached.

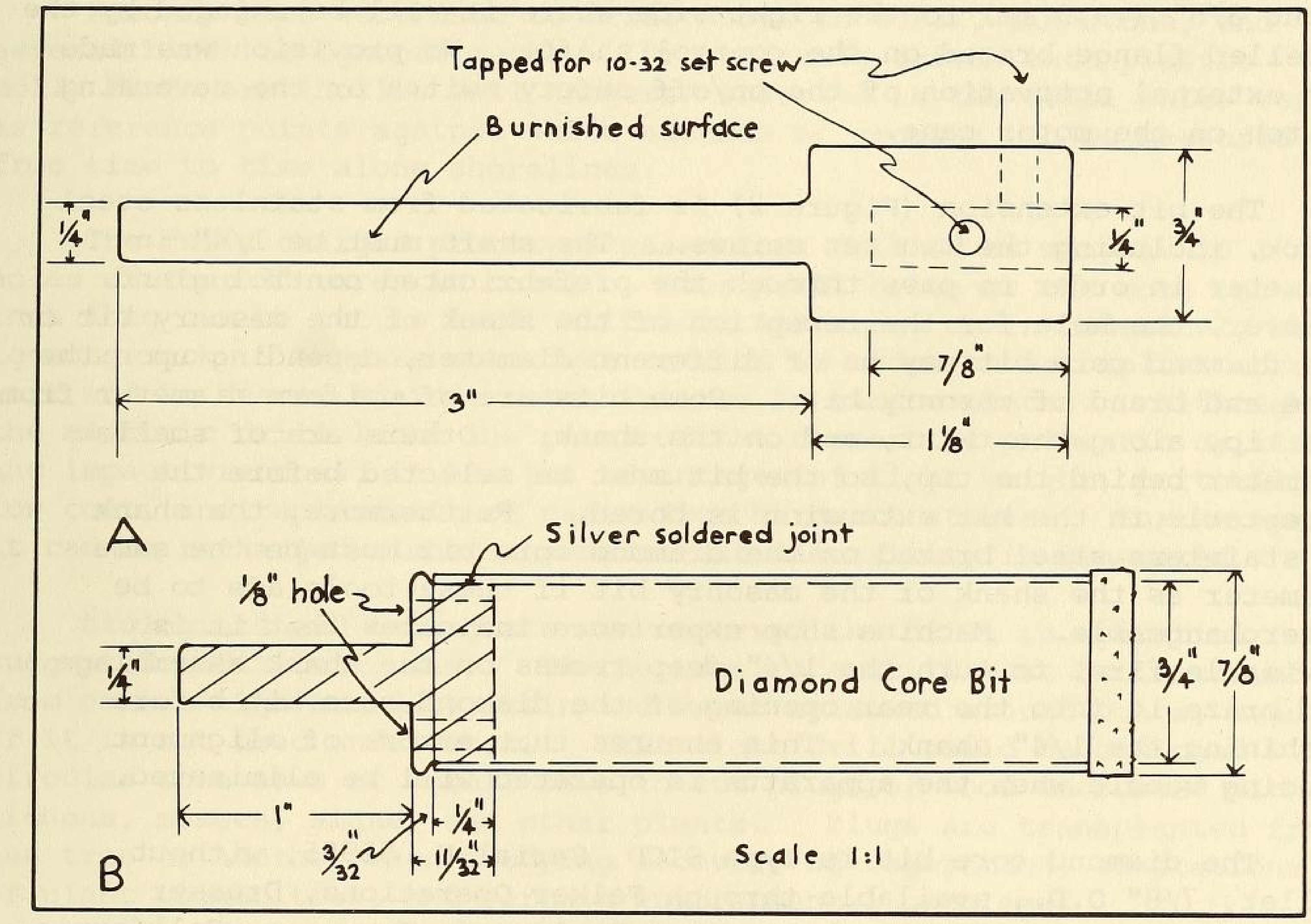

Figure 2. A. Specifications for the bit extension.
B. Specifications for the diamond core bit assemblage.

be transmitted to the electric drill. Lateral wobble of the drill handle is controlled by the oval receptacle in the base and by cushions of vinyl foam cemented to the two side walls of the housing and to the inside of the cover. The chuck key is stored inside the housing.

A short bevelled piece of shaft brazed to the long trigger release shaft at a right angle provides the contact with the trigger switch. If the case is designed with the greatest economy of inner space, the trigger release shaft will be too long to be inserted through the control gland from inside the housing. In this event a small hole can be drilled laterally through the plastic trigger on the drill and a thin diameter screw can be threaded through the hole and extended about 3/8" (=9.5 mm) to the right side where it will be engaged by the bevelled flange brazed on the control shaft. No provision was made for external activation of the on/off safety switch or the reversing switch on the motor case.

The bit extension (Figure 2) is fabricated from stainless steel stock, including the two set screws. The shaft must be 1/4" in diameter in order to pass through the prefabricated control gland. However, the hole for the reception of the shank of the masonry bit or the diamond core bit may be of different diameter, depending upon the size and brand of masonry bit. Some bits are of uniform diameter from the tip, along the twist, and on the shank. Others are of smaller diameter behind the tip, so the bit must be selected before the receptacle in the bit extension is bored. Furthermore, the shank of stainless steel brazed on the diamond core bit must be the same diameter as the shank of the masonry bit if these tools are to be interchangeable. Machine shop experience indicates that it is advisable first to turn the 1/4"-deep recess on the shank assemblage and braze it into the rear opening of the diamond core bit before machining the 1/4" shank. This ensures that errors of alignment causing wobble when the apparatus is operated will be eliminated.

The diamond core bit is Type SICD, Serial N. 55955, without collet, 7/8" O.D., available through Felker Operations, Dresser Industries, Inc., 1900 South Crenshaw Boulevard, Torrance, California, 90509. Other core bits are available in sizes as small as 1/8" and larger than the one selected, so there is a wide selection of sizes enabling a choice of bits calculated to provide the volume of material required. In ordering any brand of core bit one must specify that the bit must not have anything fastened to the open end opposite the cutting edge.

Uses

The apparatus was designed to facilitate collecting coral samples for three lines of research being conducted on various islands in the Pacific Ocean. Growth rates of some corals (for example, species of *Porites*) can be determined by X-radiography of slices taken normal to the direction of growth (Knutson, Buddemeier, and Smith, 1972). The length of the cores (about 7.5 cm or 3") and the facility with which variously oriented and positioned samples can be obtained are ideal for this line of research. Growth rates also could be determined by the ^{228}Ra, ^{90}Sr, and ^{210}Pb methods if two or more cores of 7/8" diameter were taken, or if a larger core bit were utilized (Moore, Krishnaswami, and Bhat, 1973).

Cores 7/8" in diameter weigh about 25 grams and contain enough material for either ^{14}C or uranium series ($^{230}Th/^{238}U$ and $^{234}U/^{238}U$) analyses (Barnes, Lang, and Potratz, 1956; Thurber, *et al.*, 1965). Radiometric dating of samples by these techniques is used to determine ages of raised shorelines containing corals, ages of certain reefs, and changes of sea level.

Masonry bits were used to drill holes in coral, limestone, and several kinds of igneous rocks. Bronze nails driven into plastic molly fasteners (hollow wall hangers) inserted in the drill holes serve as reference points against which amounts of erosion can be measured from time to time alone shorelines.

The fully charged prototype assemblage drilled as many as 20 1/4" holes of four 3" cores in coral. Four drill holes or one core one inch long can be cut in hard, siliceous limestone or in moderately hard igneous rock. A spare motor was carried in order to accomplish more work and to ensure against motor failure in remote places. Although the electric drill lacks the power of the commercial pneumatic drills and impact wrenches, it has the advantages of light weight, portability, low cost, and replacement of parts from hardware stores. Furthermore, it can be recharged almost anywhere that electricity is generated.

Biologists and geologists who observed the drill in operation suggested additional uses. In the tropics a drill must be insulated from normal high humidity, rain, and water splashed around boats, even if it is not used underwater. This light drill could be equipped with circular core saws or scroll saws to cut plugs of wood encrusted with lichens, mosses, algae, and other plants. Plugs are transplanted from one tree to another when studying recovery of vegetation, adaptations of plant communities, and certain environmental problems.

Attachments such as screw drivers, routers, grinding wheels, mills, and facing plates could be employed, particularly if an adjustable drill chuck were added to the bit extension.

Operation and Maintenance

Both the masonry bit and the core bit cut most effectively if the holes are kept free from cuttings. Otherwise grooves in the twist of the masonry bit become solidly packed with fine debris, preventing the cutting edges of the bit from biting into any hard ground. The core bit does not become jammed as readily as the masonry bit. Debris can be flushed from holes quite effectively using a rubber ear syringe.

It is difficult to maintain a force against a solid object when thrusting underwater, but bits cut most effectively when a steady pressure is maintained. Instructions with cutting tools warn against letting them rotate ineffectually against the surface to be cut, lest the cutting edge of the tool be damaged. Fortunately, the drill is so light or buoyant that borings can be completed in awkward situations by holding on to the work surface with one hand and operating the drill with the other.

Heat created by the motor warms the air inside the housing,causing a pressure increase. This is a beneficial development to a certain extent because the pressure differential tends to prevent leakage around the O-rings in the control glands and the cover. It is possible, although not personally observed, that long-continued operation of the motor might raise the interior air pressure to unacceptable levels. Intermittent running of the motor seems to permit adequate radiation of heat through the acrylic housing when the apparatus is submerged. It is probable that careful attention should be paid to the O-rings in cold water, for if air should leak out under high pressure, then possibly water might bypass the O-rings when the apparatus cools off. So far I have not observed any leakage in either direction in shallow water.

The O-ring around the drive shaft is subject to increased wear if it becomes dirty. Drilling generates fine abrasive material, so it is beneficial to maintain an excess of thick lubricant such as silicone grease between the shaft and the control gland. Evidence of wear appears as a grey or black stain in the lubricant near the O-ring. Periodic replacement of the O-ring and grease in the drive shaft control gland is advisable.

The steels from which both bits are made rust quickly so they should be given protective coatings of grease when not in use. Moreover, rust-prone shafts should not be left in the receptacle of the bit extension.

Modifications

The two models of drills used in the prototype require from 16 to 20 hours for total recharging. However, a later model, Skil Model 2006, is 3/8" cordless drill requiring only one hour for complete recharging. Furthermore, it has much more torque capability, greater battery capacity, and other special features, yet it has the same dimensions as the 1/4" models used in this project and therefore will fit the same housing.

Other slightly larger models of various brand names may be provided with removeable battery packs so that spare packs can be attached to the motor unit. If two drills are to be provided, it is important to verify their dimensions, because dimensions of the plastic motor cases of one model are significantly different, yet they both bear the same model number.

Some persons who have examined the drill indicate that they might tap the motor with leads that could be fastened to battery packs either in an enlarged submersible housing or carried externally.

Commercial belt packs of batteries are available for under-water photography and might be adaptable for the drill. In any case it would be necessary to ascertain the electrical engineering specifications of any motor being modified.

Acknowledgements

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Addendum

Skil Corporation recently introduced two models of 3/8 inch rechargeable drills that are interchangeable with the 1/4 inch drill originally used. The newer drills have much more torque and much faster recharge times than the 1/4 inch drill. Skil model 2003 can be recharged in three hours, whereas model 2006 can be recharged in only one hour and also has a ready light that indicates when charging is complete. The dimensions of all three drills are identical.