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Lightweight Fiberglass Feed Leg for Hand-Held Pneumatic Percussion Rock Drills

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

dBA	decibel (A-weighted network)	lbf	pound (force)
ft•lbf	foot pound (force)	pct	percent
in	inch	psi	pound per square inch
lb	pound (mass)		

LIGHTWEIGHT FIBERGLASS FEED LEG FOR HAND-HELD PNEUMATIC PERCUSSION ROCK DRILLS

By Ellsworth R. Spencer [1]

ABSTRACT

A lightweight fiberglass feed leg for hand-held pneumatic percussion rock drills has been fabricated and tested by the Bureau of Mines. Its lighter weight facilitates easier handling of the rock drill apparatus, thereby reducing the potential for back injury to the driller and increasing drilling productivity. Current hand-held feed leg drills of the same class are 50 pct heavier than the Bureau-devised feed leg drill, which is comprised of a reduced-noise drill and the fiberglass feed leg. In-mine tests of the fiberglass leg showed that its performance and cost are comparable to those of standard aluminum feed legs.

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INTRODUCTION

Hand-held pneumatic percussion rock drills, called "stopers" (for vertical holes) or "feed leg drills" (for horizontal or angled holes) are thrust into the rock by means of an air-powered cylinder called a "feed leg" (fig. 1). They are heavy (over 100 lb), bulky, and must be set up and operated by hand. Basically, a feed leg consists of two tubes, an outer tube usually made of aluminum for lightness and an inner tube made of aluminum or steel that is connected to the underside of the rock drill. The inner tube is fitted with a piston at its lower end that slides inside the outer tube when air pressure is applied. At the bottom of the outer tube is the stinger, a steel point that digs into the ground for support of the feed leg and rock drill. A steel bushing fitted to the top end of the outer tube guides the inner tube when it is extended. Pressurized air is passed through the center of the inner tube and piston and forces them to slide forward, therby providing thrust to the drill.

The feed leg provides vertical and horizontal thrust while the drill operator provides the needed directional thrust. During drilling, the weight of the rock drill must be balanced between the forces being exerted by the feed leg and the driller; otherwise, the drill will "hang" on the steel. As the hole gets deeper, the inner tube slides out until it is fully extended. More drill steel is then added, or the inner tube is retracted and the feed leg repositioned, or both.

RATIONALE

Although standard aluminum and steel feed legs do not present serious health and/or safety problems by themselves, they have received attention from the Bureau of Mines because they are used on hand-held mining drills, which do present such problems. Noise is the greatest health hazard associated with these drills; noise levels of standard drills commonly range from 115 to 120 dBA or greater. Because Federal regulations do not permit continuous noise levels above 115 dBA, the mere startup of these drills can result in operator overexposure. In addition, the excessive vibration of the drill handle can lead to Raynaud's ("white finger") disease, an affliction characterized by severe damage to arteries and tissues of the fingers. The frequent manual repositioning of the drill can cause muscle pulls and other injuries because of the weight (over 100 lb) and awkwardness of the drill-leg configuration.

In conjunction with Bureau efforts to devise "quiet" hand-held mining drills,[2] a lightweight fiberglass feed leg has been fabricated. The major advantage of fiberglass as the feed leg material is that its high strength-to-weight ratio results in a lower overall drill weight. In fact, the combined weight of a standard drill with an aluminum leg is 50 pct more than the combined weight of the fiberglass leg and the quiet drill developed by the Bureau (table 1). Miner acceptance of the quiet drill is increased due to the presence of the fiberglass feed leg, and the likelihood of injury while repositioning the drill is reduced. The lighter weight could also lead to an increase in miner productivity due to a reduction in hole-to-hole repositioning time. Another potential but unproven benefit of the fiberglass feed leg, even when used on standard drills, is a reduction in the noise and vibration emanating from the feed leg itself.

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[2]Creare Products, Inc. Development of Commercial Quiet Rock Drills. Ongoing BuMines contract J0177125; for inf., contact W. W. Aljoe, TPO, Pittsburgh Research Center, BuMines, Pittsburgh, PA.

Creare Products, Inc. Development of Prototype Quiet Hard Rock Drills. Ongoing BuMines contract H0113034; for info., contact W. W. Aljoe, TPO, Pittsburgh Research Center, BuMines, Pittsburgh, PA.

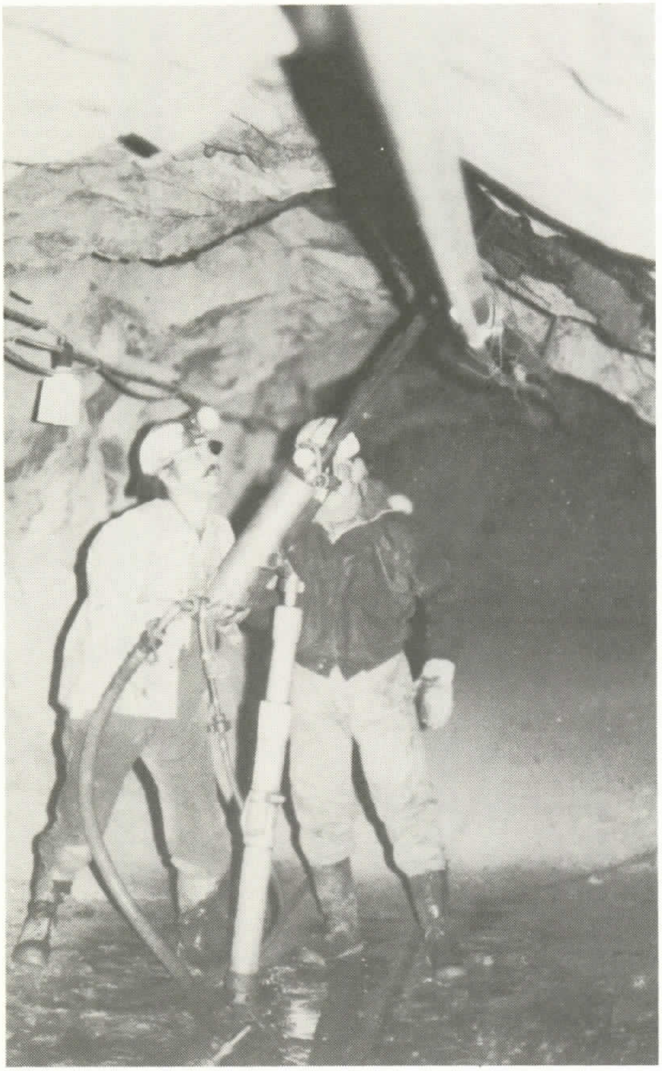

FIGURE 1. - Standard aluminum feed leg on hand-held percussion drill.

Another area of consideration for comparison is cost. The greatest difference is in the tubing; the inner components are similar and are low in cost, so they have little effect on the total costs. The fiberglass tubing costs are considered high because they represent small-order pricing, not large-volume discounts. The final price at production level is arbitrary for the fiberglass feed leg because of this and other variables, and is reflected as a wide price range in table 2.

TABLE 1. - Comparisons of rock-drill and feed-leg weights, pounds

	Bureau[1]	Standard[2]
Feed leg.............	18	30
Hard rock drill......	50	73
Total..........	68	[3]103

[1]Fiberglass feed leg, "quiet" drill.
[2]Aluminum feed leg.
[3]51 pct heavier than Bureau feed leg drill.

TABLE 2. - Approximate costs of feed legs, dollars

	Feed leg	
	Fiberglass	Standard Al
Tubing cost.....	200	100
Total cost......	475	375
Selling price[1]..	575-800	600-700

[1]Estimated.

DESIGN

The construction of the fiberglass feed leg is similar to that of aluminum feed legs. Figure 2 shows the individual components of the fiberglass feed leg; the drawing in figure 3 shows its overall dimensions. The outer fiberglass tube provides containment of the pressurized air for extension and force. A piston with leather seals is connected to the inner tube, also made of fiberglass, which slides relative to the outer tube. Aluminum is used for the piston parts, bushings, end cap, and bearing sleeves.

To provide the thrust required for a hard rock drill (over 600 lbf), a special fiberglass-wound tube developed for hydraulic cylinders and pressure vessels was selected for the outer and inner tubes. These new fiberglass cylinders are available in the required dimensions "off-the-shelf." A cross-weave fiberglass tube has ultimately been selected over a single-weave tube used for preliminary testing. The newer tube has the better flex and strength characteristics that are a concern in the rock drilling environment, even though the earlier tube has performed well under very stressful conditions. The material properties of

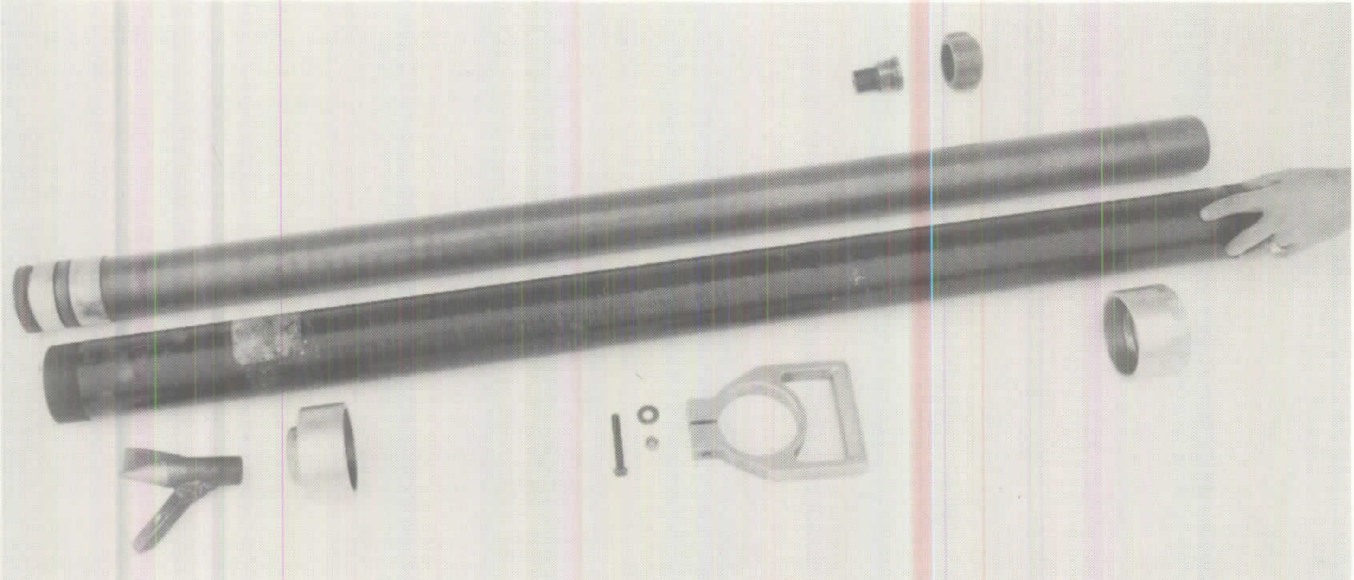

FIGURE 2. - Components of fiberglass feed leg.

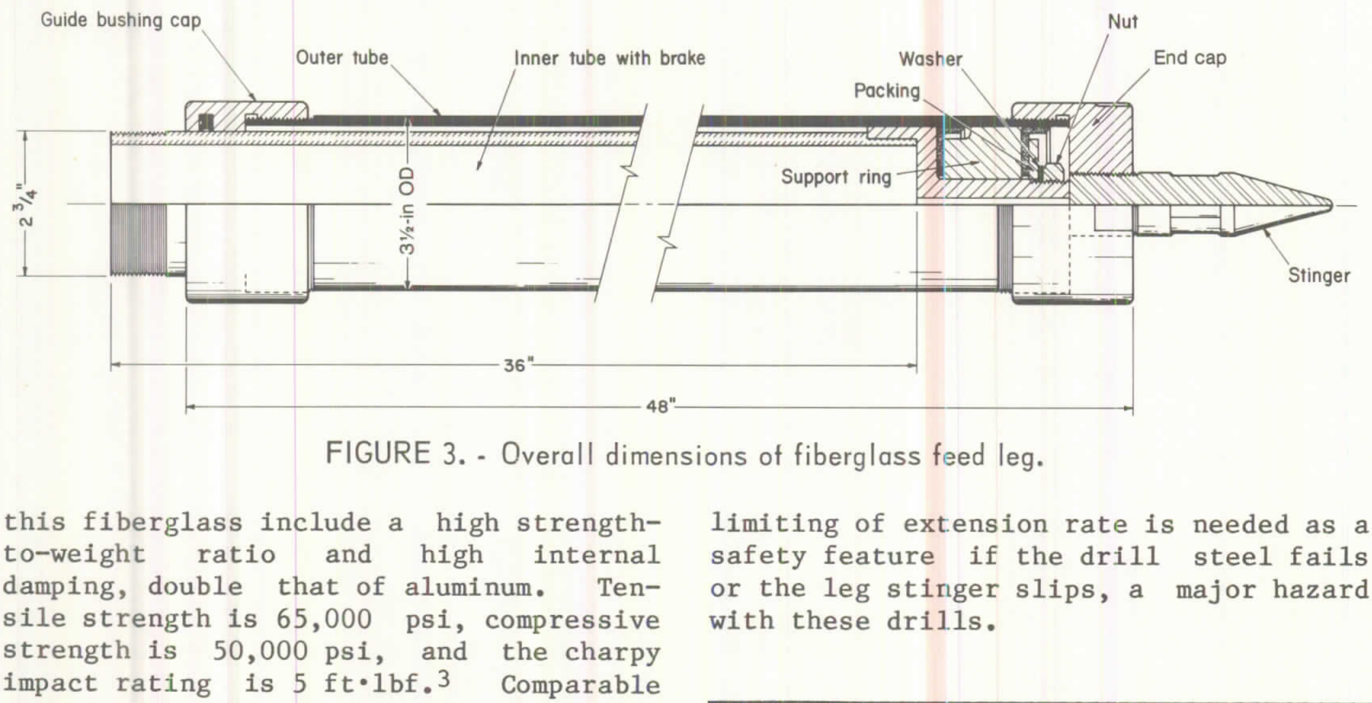

FIGURE 3. - Overall dimensions of fiberglass feed leg.

this fiberglass include a high strength-to-weight ratio and high internal damping, double that of aluminum. Tensile strength is 65,000 psi, compressive strength is 50,000 psi, and the charpy impact rating is 5 ft•lbf.[3] Comparable aluminum tubing of 2024 alloy has 70,000 psi tensile strength and a charpy impact rating of 3 ft•lbf.

A return spring with rate of extension brake is also built into the leg. This return spring and brake fit inside the outer tube to provide a retraction force and limit the rate of leg extension. The limiting of extension rate is needed as a safety feature if the drill steel fails or the leg stinger slips, a major hazard with these drills.

[3]Charpy impact is a pendulum-type, single-blow impact test in which the specimen, usually notched, is supported at both ends as a simple beam and broken by a falling pendulum. The energy absorbed, as determined by the subsequent rise of the pendulum, is a measure of the impact strength or notch toughness.

TESTING

To verify the potential value of fiberglass feed legs on both the standard and the Bureau devised quiet drills, Tech Enterprises, Inc.,[4] a small manufacturer of hand-held rock drills agreed to design, build, and test a prototype for the Bureau. Tech Enterprises' expertise in this area and the initial testing at the Colorado School of Mines Experimental Mine provided valuable information that led to the final design of the leg. Two different drill-mounting methods were used, an "offset stoper" version (fig. 4) and a standard feed leg version (fig. 5).

During initial testing, the feed leg provided enough thrust (about 200 to 400 lbf) to stop drill steel rotation; however, several minor modifications were made to counteract problems that arose. First, the mounting clamps failed and slipped on the outer fiberglass tube. To eliminate this problem, the outer tubing was threaded, and a new mount was designed to reduce the bearing pressure needed to hold the clamps firmly to the tube. Second, a Nylatron bearing caused sticking and scoring inside the leg; an aluminum replacement bearing eliminated this. Third, elastomer seals were replaced with leather seals because of sticking and bonding problems between the elastomer and the fiberglass.

[4]Reference to specific manufacturers and materials does not imply endorsement by the Bureau of Mines.

FIGURE 4. - Offset stoper version of fiberglass feed leg.

FIGURE 5. - Standard version of fiberglass feed leg.

In-mine testing showed that the thrust capability of the feed leg was unchanged after the modifications were made. Impacts of rocks during drilling and transport of the drill with feed leg attached did not damage the fiberglass surface. Further testing is planned with production mines in Canada, South Dakota, Colorado, and Wyoming that have expressed interest in the new drill and fiberglass feed leg to ensure that the new materials will perform over an extended period.

SUMMARY

The fiberglass feed leg has performed as expected and shows potential as a lightweight, highly damped, and lower vibrating alternative to the standard aluminum and steel feed legs; drill operators consistently have preferred the lightness and balance of the fiberglass feed leg. About 80 holes have been drilled using the fiberglass feed leg with the usual minor problems in prototype equipment being found and corrected.

During early testing for noise attentuation, comparisons between the fiberglass feed leg and an aluminum feed leg indicated little or no noticeable noise reduction. This can be attributed to the much higher noise level of the rock drill during operation. While actual use demonstrated no obvious noise reduction, the vibration damping and weight advantages support the continued development and use of the fiberglass feed leg.

More testing is required to determine compatibility and durability of the fiberglass tubes and aluminum bearing components. A commercial firm plans to manufacture and test the lightweight, Bureau devised quiet rock drills with fiberglass feed legs in several mines. Preliminary reports indicate the company's willingness to produce the feed leg for commercial use when tests are sucessfully completed. Although the cost of the prototype fiberglass feed leg was higher than that of an aluminum feed leg, the cost of the commercial fiberglass feed leg is expected to be much lower.

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