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TITLE: GEOTHERMAL TURBODRILL FIELD TESTS

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# GEOTHERMAL TURBODRILL FIELD TESTS

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## ABSTRACT

A new advanced geothermal turbodrill designed to operate at temperatures in excess of 500°F has been field tested in LASL's EE-2 hot, dry rock well. The operating characteristics of 5-3/8- and 7-3/4-in. turbodrills were measured on a dynamometer test stand, and then these tools were used to drill Texas Pink granite in the laboratory at rates in excess of 50 ft/hr. This compares to 10 ft/hr with conventional bits. A 7-3/4-in. turbodrill was then used to drill a 57 ft interval in granodiorite at LASL's Fenton Hill Hot Dry Rock geothermal site with a 12-1/4-in. insert roller bit. The turbodrill drilled at an average rate of 23 ft/hr compared to 10 ft/hr for conventional bits operated at 60 rpm. Plans are being made to use these turbodrills in the directional portions of LASL's hot, dry rock geothermal wells.

## INTRODUCTION

LASL recently field-tested the advanced geothermal turbodrill shown in figure 1. This geothermal turbodrill contains no elastomers and is designed to operate at temperatures in excess of 500°F. This high-torque turbodrill is designed to drill the hard rocks encountered in geothermal wells. These turbodrills are currently being built in 5-3/8- and 7-3/4-in. diameters, with 3-1/4- and 9-5/8-in. diameter tools becoming available in the near future.

These turbodrills contain large roller thrust bearings that allow the application of the high bit weights needed for fast drilling in hard rock. Advanced turbine blades deliver 4 to 5 times more torque than the turbine blades used in existing turbodrills, thereby allowing the application of high bit weights. The turbodrills are designed to operate roller bits at 150 to 250 rpm and diamond bits at 400 to 800 rpm. Approximately 10 percent of the drilling fluid is circulated through the roller bearings to cool and lubricate them. The remaining fluid flows through the bit to remove the rock cuttings from the hole bottom. Additional details on this turbodrill are contained in the references (Maurer *et al.*, 1977 and Maurer *et al.*, 1978).

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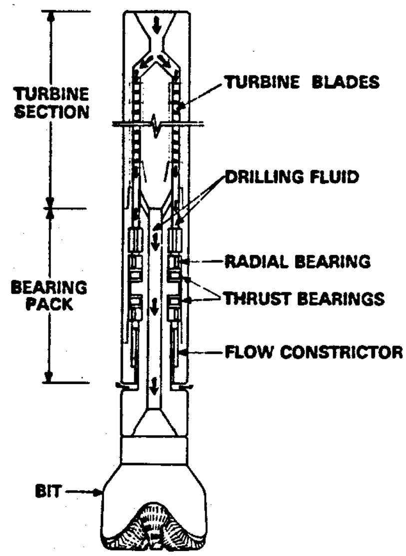


Fig. 1 High-temperature geothermal turbodrill.

## DYNAMOMETER TESTS

The performance characteristics of these geothermal turbodrills were measured in the dynamometer test stand shown in figure 2. Water was pumped through the turbodrills by Dowell and Halliburton oil field pump trucks. A dynamometer was used to apply torque to the turbodrill. The turbodrills were operated at speeds of 0 to 2,000 rpm during the dynamometer tests.

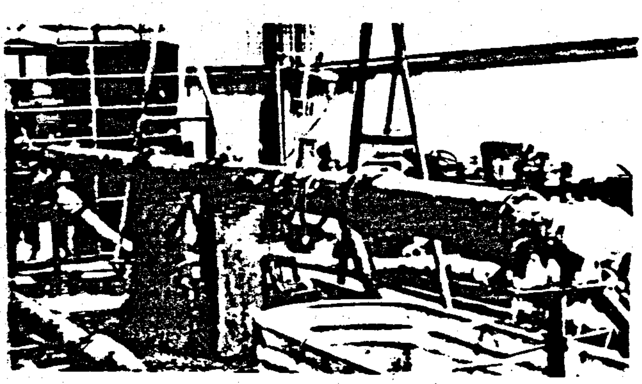

Fig. 2 Turbodrill in dynamometer test stand.

Table 1. Geothermal turbodrill operating characteristics

| Turbodrill Diameter (In.) | Flow Rate (gpm) | Torque Output (ft-lb) | Rotary Speed (rpm) | Power Output (hp) |
|---|---|---|---|---|
| 5-3/8 | 200 | 330 | 200 | 13 |
| 5-3/8 | 200 | 260 | 1000 | 49 |
| 5-3/8 | 250 | 540 | 200 | 20 |
| 5-3/8 | 250 | 490 | 1000 | 93 |
| 5-3/8 | 300 | 820 | 200 | 31 |
| 5-3/8 | 300 | 680 | 1000 | 129 |
| 5-3/8 | 350 | 1100 | 200 | 42 |
| 5-3/8 | 350 | 830 | 1000 | 158 |
| 7-3/4 | 350 | 880 | 200 | 34 |
| 7-3/4 | 350 | 630 | 600 | 72 |
| 7-3/4 | 400 | 1120 | 200 | 43 |
| 7-3/4 | 400 | 780 | 600 | 90 |
| 7-3/4 | 450 | 1400 | 200 | 54 |
| 7-3/4 | 450 | 990 | 600 | 113 |
| 7-3/4 | 500 | 1720 | 200 | 65 |
| 7-3/4 | 500 | 1210 | 600 | 138 |

The operating characteristics for 50 stage 5-3/8- and 7-3/4-in. turbodrills are shown in Table 1. The output torque and output power of the turbodrills can be doubled by using 100 turbine stages in these tools.

## LABORATORY DRILLING TESTS

In April 1979, a series of drilling tests was conducted with the geothermal turbodrills at the Terra Tek Drilling Research Laboratory (DRL) in Salt Lake City, Utah. Figure 3 shows the 7-3/4-in. diam turbodrill in the full-scale DRL drilling rig. This drill rig is equipped with a 1600 horsepower Continental Emsco F1600 mud pump, which was used to circulate fluid through the turbodrills during the tests.

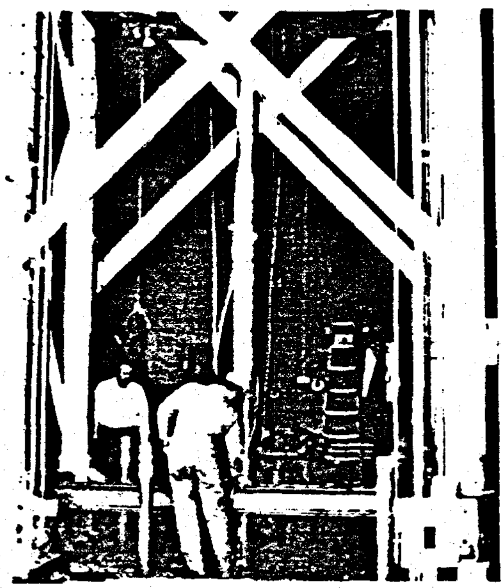

Fig. 3 Geothermal turbodrill in DRL drill rig.

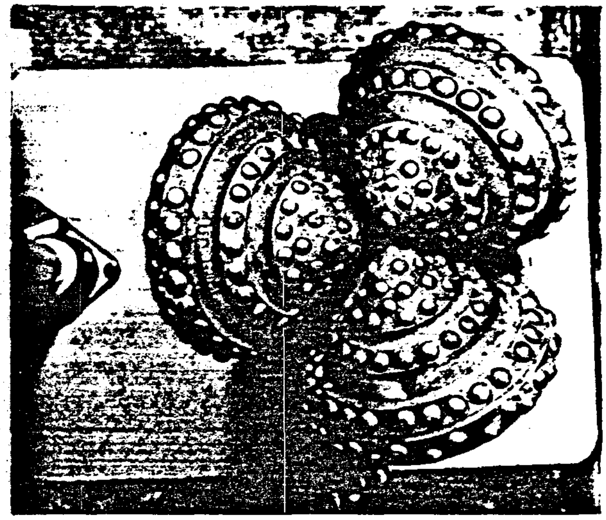

Fig. 4 Insert roller bit used with turbodrill.

Drilling tests were conducted in 4- by 5- by 5-ft blocks of Texas Pink granite that weighed approximately 8 tons. This granite was selected because its strength and drilling characteristics are similar to that of the granodiorite encountered at LASL's Fenton Hill site.

Insert roller bits were used to drill Texas Pink granite. Figure 4 shows a 12-1/4-in. insert roller bit used on the 7-3/4-in. turbodrill. The bearings and inserts in this bit were in excellent condition at the end of the 4-hr drilling tests.

The speed of the turbodrills was controlled by varying the bit weight and the flow rate. After some experimenting, the speed of the 7-3/4-in. turbodrill could be controlled at 200 to 300 rpm when drilling the granite samples. The 5-3/8-in. diam turbodrill is a higher speed tool because of its smaller diameter. This smaller turbodrill could be operated at rotary speeds of 300 to 500 rpm when drilling the granite samples.

The result of these laboratory tests was an operating map, figure 5.

## FIELD TESTS

The 7-3/4-in. geothermal turbodrill was tested in LASL's EE-2 hot, dry rock geothermal well at Fenton Hill, New Mexico, in June 1979. Figure 6 shows the turbodrill in the drilling rig. A high-temperature shock absorber was used between the bit and the turbodrill to reduce impact loads on the turbodrill thrust bearings.

The geothermal turbodrill reamed 150 ft before reaching the hole bottom and then drilled the 57 ft interval from 4,855 to 4,912 ft. The drilling rate of this interval averaged 23-ft/hr compared to 10 ft/hr with conventional

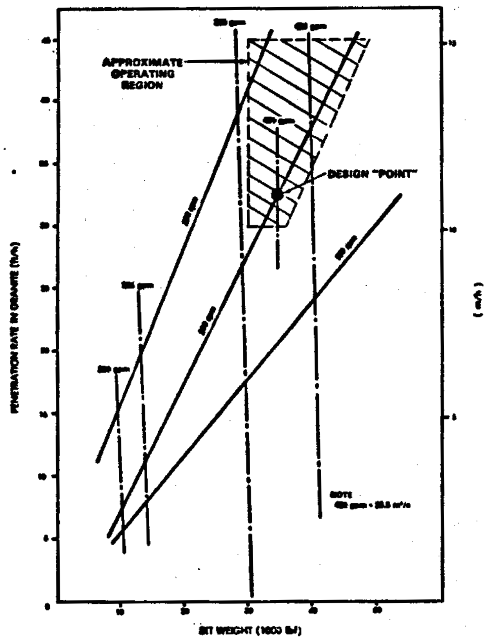


Fig. 5 7-3/4-in. geothermal turbodrill performance characteristics.

drilling (60 rpm). After drilling this interval, the insert roller bit was worn out and had to be replaced. Excessive gauge wear indicated that the bit was worn while it reamed the hole or that it was operated at a very high rotary speeds by the turbodrill. A tachometer currently being developed by the Morgantown Energy Technology Center will be used to measure

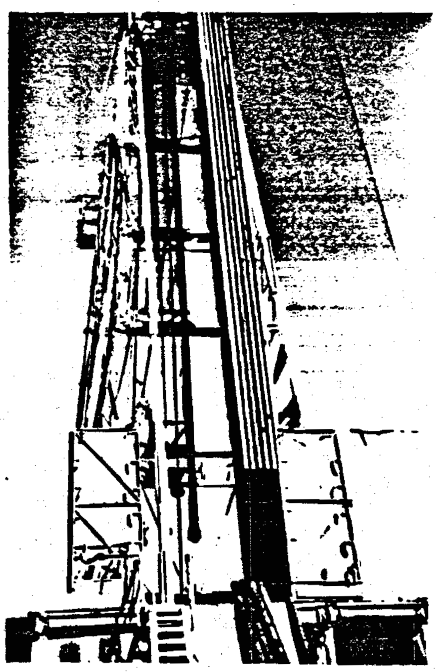

Fig. 6 Turbodrill in drilling rig.

the turbodrill speed during future tests. The tachometer should allow good control of the turbodrill speed, thereby increasing the bit footage and reducing the bit gauge wear problem.

This initial field trial was made using the operating map of figure 5, and operation approached the design point.

Plans are being made to conduct additional turbodrill tests at Fenton Hill during July 1979. Results of these tests will be presented during the oral presentation of this paper.

## REFERENCES

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