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DEVELOPMENT OF THE CLAW HAMMER SCALING TOOL

Contract H0202025

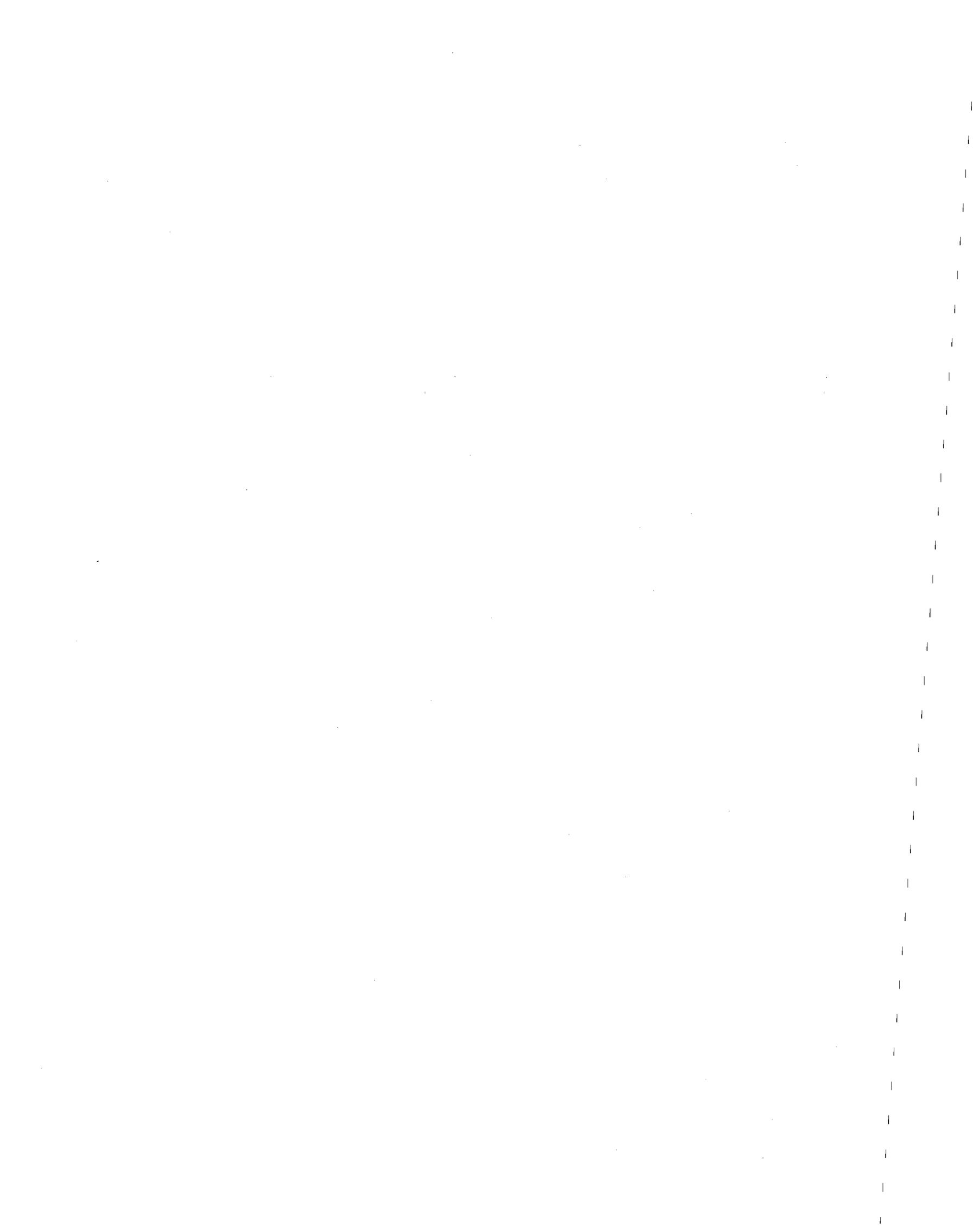
Battelle, Pacific Northwest Laboratories

Bureau of Mines Open File Report 26-86

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16. Abstract (Limit: 200 words) <p>To improve safety, economy, and efficiency of scaling in underground metal or nonmetal mines, research was conducted to develop a combination prying-hammering tool for machine scaling. In the prototype claw-hammer assembly, a hydraulic impact hammer was used to drive the claw mechanism into the rock. After a bite was established, the loose rock could be removed using a hydraulically actuated prying motion. This tool combines the advantages of both impact and ripper type scaling tools and provides versatility for use in most rock types. The prototype was subjected to limited testing (1) to verify its operational functions and (2) to assess its potential capability in future underground testing. The prototype was first bench tested to hydraulically test the independent functions. It was then mounted on a backhoe boom for some preliminary field testing. Both claw and hammering functions operated successfully on concrete and quartzite boulders.</p>					
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FOREWORD

This report was prepared by Battelle, Pacific Northwest Laboratories of Richland, Washington, under USBM Contract number H0202025. The contract was initiated under the Mine Safety Program. It was administered under the technical direction of the Spokane Mining Research Center with Mr. J. P. Conway acting as Technical Project Officer. Mr. R. J. Simonich was the contract administrator for the Bureau of Mines. This report is a summary of the work recently completed as part of this contract during the period April 23, 1982, to December 29, 1983. This report was submitted by the authors on December 29, 1983.

The author wishes to acknowledge Battelle colleagues D. E. Rasmussen, former project manager, and L. C. Todd, senior designer, for their contributions to the successful completion of this work. Thanks are extended also to Advanced Industries, Inc., of Portland, Oregon, for their help in fabricating and bench-testing the prototype claw-hammer tool. Special appreciation is expressed to technicians at the USBM Spokane Research Center who, under the direction of John Conway, helped with preliminary field testing of the claw-hammer scaling tool.

J. D. Eklund
Project Manager



SUMMARY

This report describes modified Phase II of the project, Development of a Mechanized Scaler, performed by Battelle, Pacific Northwest Laboratories for the Bureau of Mines. The objectives of Phase II were to design, fabricate, and bench test a prototype combination claw-hammer tool for machine scaling.

In the prototype claw-hammer assembly, a hydraulic impact hammer is used to drive the claw mechanism into the rock. After a bite is established, the loose rock can be removed using a hydraulically-actuated prying motion. This technique combines the advantages of both impact and ripper-type scaling tools and provides versatility for use in most rock types.

The prototype was first bench-tested to hydraulically test the independent functions. It was then mounted on a backhoe boom for some preliminary field testing. Both claw and hammering functions operated successfully on concrete and quartzite boulders. Tests of actual scaling performance were outside the scope of the project.

The limited testing demonstrated that the design is viable. However, further testing, particularly of scaling in an actual mine environment, is warranted.



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FOR BUREAU OF MINES USE ONLY

This document contains information which is subject to a Battelle, Pacific Northwest Laboratories' Invention Report G220 entitled "Combination Hammer Claw Scaling Mechanism," with Donald Edger Rasmussen listed as the inventor. This invention report was submitted to the Bureau of Mines March 2, 1981, and this case was assigned their No. MIN 3107. It was acknowledged by return letter dated May 29, 1981. To protect the patentability and proprietary nature of this material, it is understood that this document will not be used outside of the U.S. Bureau of Mines, and will not be copied or further disseminated without the written consent of Battelle, Pacific Northwest Laboratories.

DEVELOPMENT OF THE CLAW-HAMMER SCALING TOOL -
PHASE II

INTRODUCTION

Proper scaling is necessary for safe operation during any underground mining activity. This need is documented in the mandatory regulations for scaling found in 30 CFR 57.⁽¹⁾ In many U.S. mines operating today, scaling is accomplished by manually barring-down the loose material from around the mine opening. Barring-down requires a great deal of physical strength, endurance, and judgment to safely scale an underground opening. In addition to being one of the most physically demanding activities underground, it is one of the most dangerous. As recent accident statistics^(2,3) indicate, a large percentage of the "fall of ground" accidents and fatalities is directly related to manual scaling. Consequently, safer scaling practices are needed within the mining industry.

In addition to the definite safety hazard, adverse economic factors are also associated with manual scaling. Lost-time accidents and fatalities represent a significant direct cost in terms of the loss of skilled miners and a more indirect cost in terms of increased premiums on Workman's Compensation insurance. Despite the recent trend toward mechanization in underground mining systems, scaling remains primarily a manual operation. Further, it can be a very time- and labor-consuming process. Hence, as labor costs increase, the cost of scaling using current practice will become an increasingly larger percentage of production costs.

These safety and economic considerations point out a definite need within the underground mining industry for mechanized scaling systems. This need has promoted the development of such systems in the large, room-and-pillar, metal/nonmetal mines in the United States and Europe. However, the mechanized scalers currently available are very large; thus, their use is limited to only the larger-scale underground mining operations. A need remained for a scaling tool that can work in the smaller openings typical of most U.S. mines. To

meet this need, the Bureau of Mines contracted with Battelle, Pacific Northwest Laboratories, to develop a mechanized scaler for the smaller sized mines.

Phase I of the project entitled Development of a Mechanized Scaler involved assessment and preliminary design of two mechanized scalers.⁽⁴⁾ Preliminary designs were successfully completed for both machines. These designs included chassis, highly articulated booms, and combination claw-hammer scaling tools, for use in mine openings ranging from 8 ft x 8 ft to 12 ft x 14 ft. As originally scoped, Phased II was to include detailed design of one of the scaling machine designs completed during Phase I. Subsequent funding restrictions, however, limited Phase II efforts to further development of a unique combination claw-hammer concept that emerged during Phase I.

This report documents the design, fabrication, and testing of a prototype combination claw-hammer tool for machine scaling. The design work was performed at the Richland, Washington, facilities of Battelle, Pacific Northwest Laboratories. Prototype fabrication and quality assurance testing were done by Advanced Industries, Inc., of Portland, Oregon. The preliminary field tests were conducted at the USBM Spokane Mining Research Center, Spokane, Washington.

CLAW-HAMMER SCALING TOOL

Most mechanized scalers are of two types. The first type uses a hydraulically actuated hook or claw to pry loose rock from the mine opening. Machines of this type use the "brute force" approach to scaling. The second type uses a hydraulic impact hammer to remove the loose rock. Most of the hammers are generally quite large, in the 500 to 1000 ft-lb range, and remove the loose rock by impact force and, to some extent, by wedging action.

The success of any type scaling tool is largely dependent on the type of rock in which it is working. Claw-type tools tend to work best in laminated or slabby ground where it is easy to get behind a loose slab and pull it down. On the other hand, the impact hammers appear to work better in more blocky ground where cracks and fractures are not as accessible. Mine operators have expressed concern that the large impact hammers currently being used may tend to damage the roof. Although most operators using the impact hammers reported feeling this problem was not significant, they did admit that the large hammers can actually mine the opening.

The evident limitations of both "brute force" and powered scaling, when used independently, suggested combining the better features of both into a single assembly. Such a combination could be used in a wider range of mine sizes and in various and changing rock conditions.

The claw-hammer assembly developed by Battelle offers the combined versatility of a hydraulically actuated claw for prying down scale and a small hydraulic hammer for chiseling down scale. The major components of the claw hammer are illustrated in Figure 1. Table 1 lists the overall specifications of the claw hammer. The assembly's small size and light weight allows it to be boom-mounted on a vehicle small enough to negotiate the smaller underground mine openings.

The claw and the hydraulic hammer are structurally supported and protected by the two side plates. The hammer is clamped between the side plates with through bolts. Additionally, the upper spring anchor and the lower protective plate help to cross-tie the side plates. These features are shown in Figure 2, an exploded view of the components.

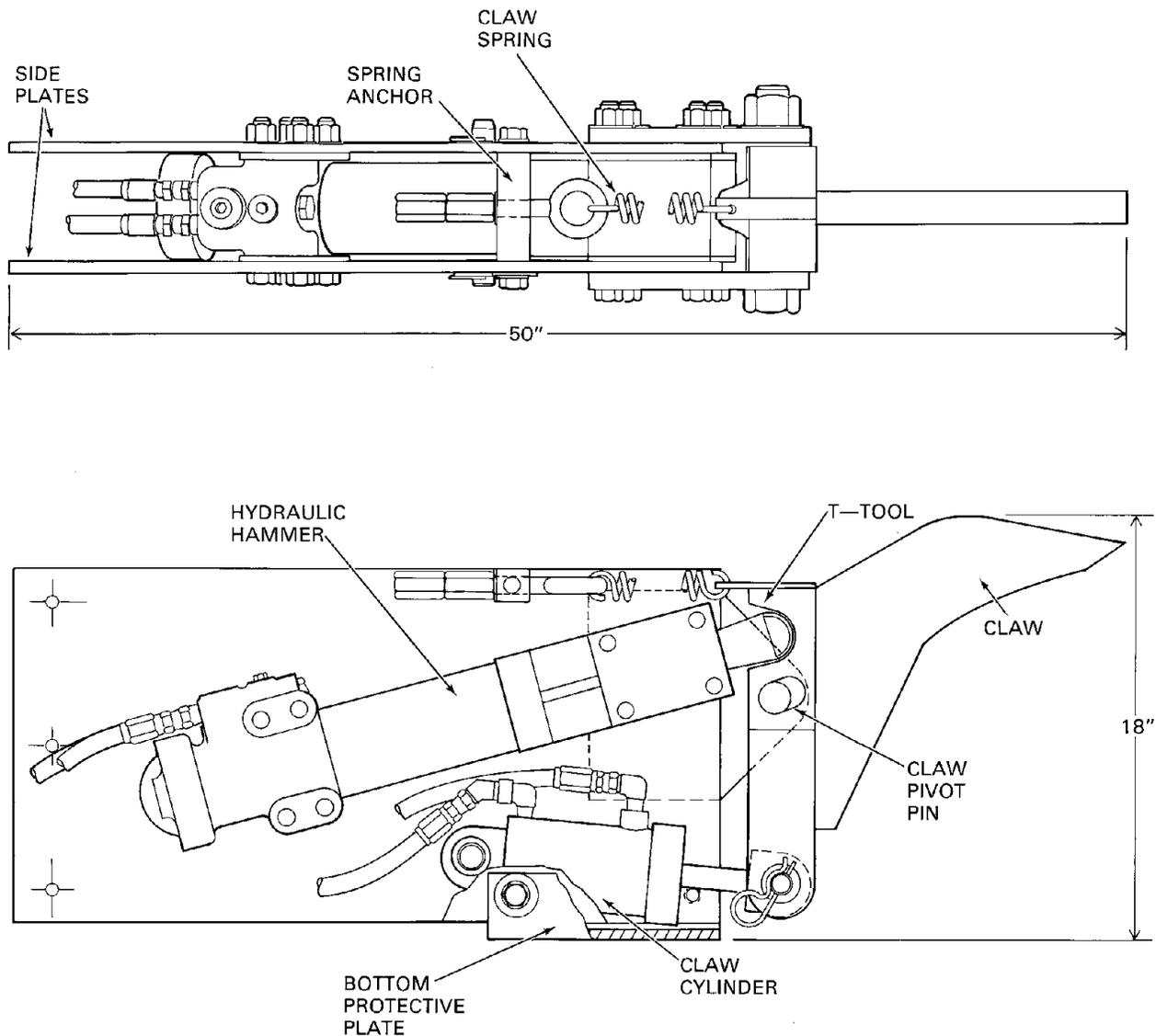


FIGURE 1. Claw-Hammer Assembly Major Components

The claw (Figures 3 and 4) is retained between the front of the side plates by a pivot pin through a slot in the claw; the slot is slightly longer than a hammer stroke. A hydraulic cylinder is attached to the lower end of the claw through a clevis arrangement and is pinned to the side plates at its other end. When retracted, the cylinder causes the claw to rotate about the pivot pin to provide the necessary prying motion of the claw's tip. The

TABLE 1. Claw Hammer Scaling Tool Specifications

ITEM	SPECIFICATIONS	
Overall Assembly	Length	- 4 ft 2 in.
	Width	- 10 in.
	Height	- 18 in.
	Total Weight	- 325 lb
Claw	Overall length	- 17 in.
	Overall width	- 5-3/4 in.
	Overall height	- 19 in.
	Tip insertion length	- 9 in.
	Tip width	- 1-1/2 in.
	Weight	- 60 lb
	Material	- ASTM A514 @ 40-45 R _c Hardness
	Claw cylinder diameter	- 3-1/4 in.
	Claw cylinder stroke	- 2 in.
	Claw cylinder hydraulic pressure	- 2000 psig max.
	Claw tip sweep	- 4 in. max.
	Claw tip prying force ^(a)	- 25,000 lb max.
Hammer	Hammer make & model (used in prototype)	- Tramac Model BRH-40 ^(b)
	Overall length	- 26 in.
	Overall width	- 5 in.
	Overall height	- 7-1/2 in.
	Hammer hydraulic pressure	- 2000 psig max.
	Hammer hydraulic flow rate	- 8 gpm max.
	Hammer blows per minute	- 1200
	Hammer blow energy	- 115 ft-lb max.

(a) This figure assumes maximum cylinder retraction force leveraged with the claw's fulcrum point 9 in. from the working tip of the claw. It also ignores any boom reaction forces.

(b) Reference to specific brands, equipment, or trade names in this report is made to facilitate understanding and does not imply endorsement by the Bureau of Mines.

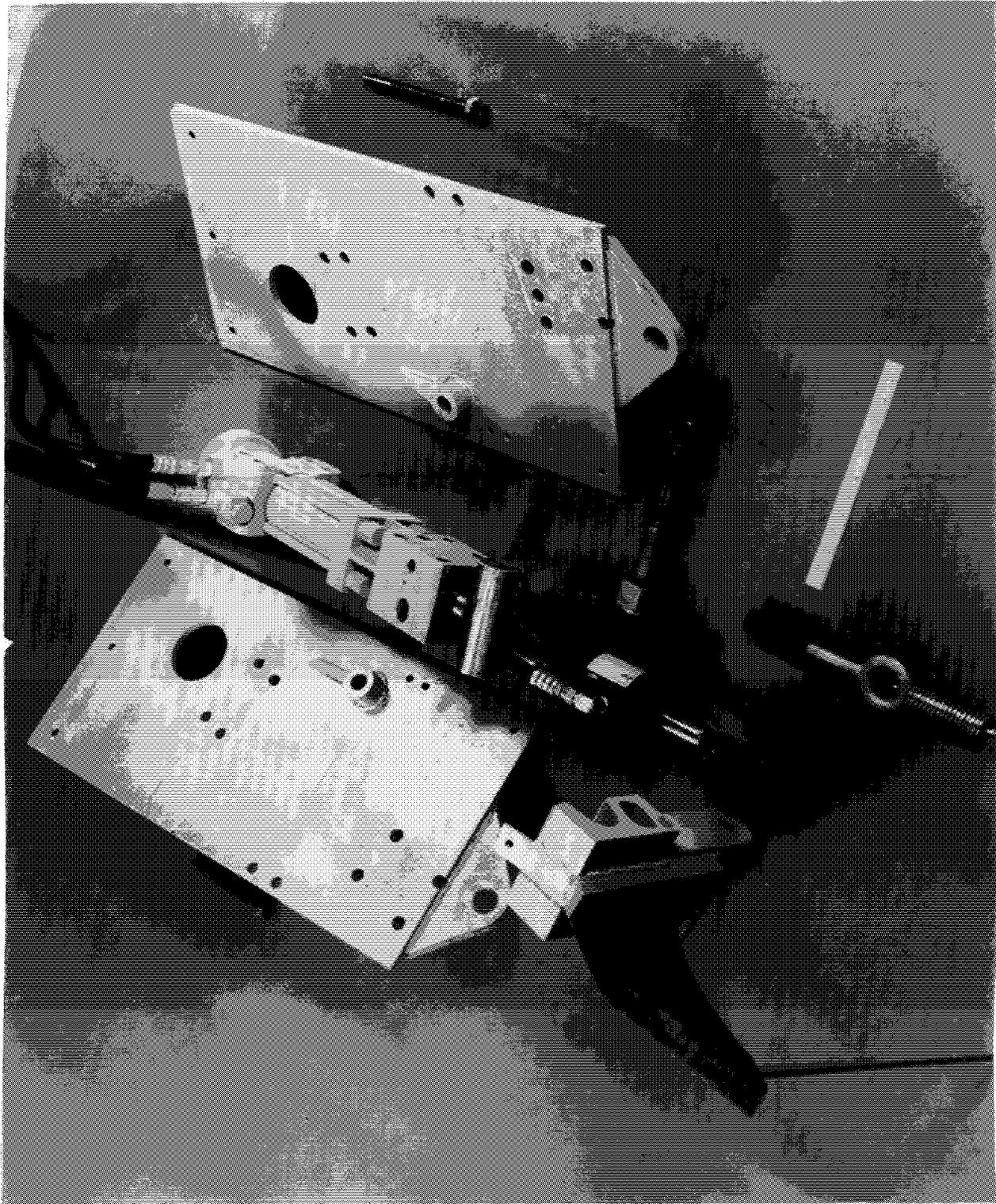
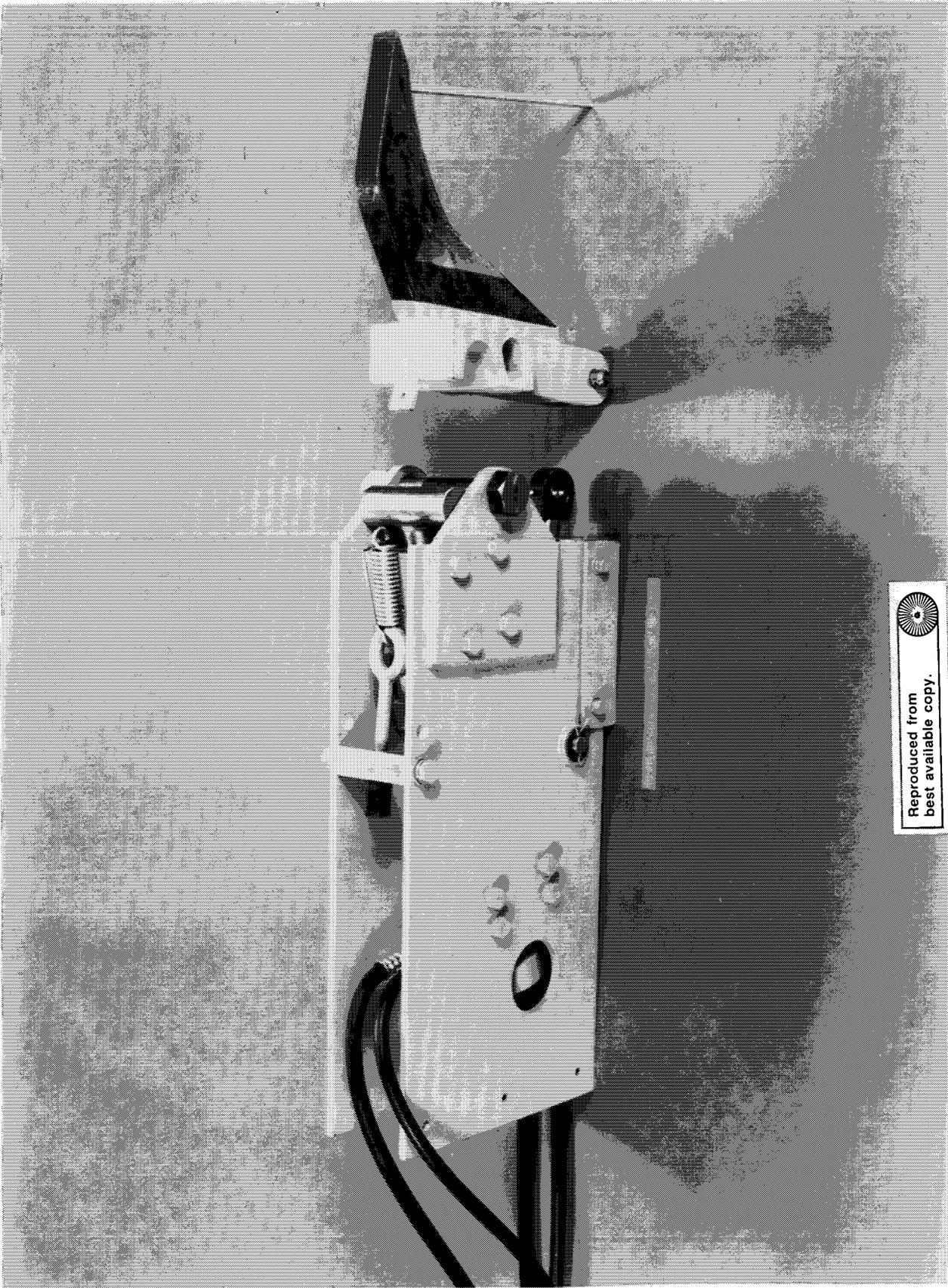


FIGURE 2. Claw-Hammer Assembly Major Components



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FIGURE 3. Claw Detached from Rest of Assembly



FIGURE 4. Prototype Claw-Hammer Assembly

initial part of the rotation also unloads the T-tool to protect the hammer from excessive side loading. The claw is configured with a narrow tip and a curved shank so that the pivoting action causes a prying action between the claw and the rock, analogous to that achieved with a hand-scaling bar. The advantage of this arrangement is clear. The heavy prying loads are transmitted between the claw and the rock, and not to the rest of the claw hammer assembly and boom.

The top of the claw is spring-loaded, which helps maintain contact between the T-tool and the hammer. This not only improves stability during the hammering mode but also helps to lessen wear and, possibly, reduce breakage of the T-tool and claw by controlling unrestrained rebounding of these parts.

The T-tool delivers the hammer blows from the hydraulic hammer to the claw. Its shank is inserted into the hammer and retained the same way as a standard tool for this hammer. The cross-T of the tool fits into a mating recess in the claw to help resist overturning rotation of the claw when being side loaded. The cross-T also helps distribute the hammering loads over a larger surface area between the claw and itself.

Although necessarily compact to meet the design need for a small scaler, the hydraulic hammer (Figure 5) has significant capacity for its size. The blow energy rating is 115 ft-lb. The hydraulic hammer impacts the T-tool, which, in turn, impacts the claw. The line of force coincides with the top of the claw, causing it to operate as a chisel. Thus, the vibrating claw can scale by itself in stable formations, or can augment the prying mode in less stable formations.



FIGURE 5. Hydraulic Hammer

TESTING PROCEDURES AND RESULTS

The prototype claw-hammer was subjected to quality assurance bench tests and some preliminary field tests. Tests of actual scaling performance were outside the scope of this phase of the project.

QUALITY ASSURANCE TESTING

After fabrication, the claw-hammer assembly was tested on a hydraulic test bench (Figure 6) under the direction of the prototype's fabricator, Advanced Industries, Inc., of Portland, Oregon. While the hammer was being run through its motions, a slight interference was found between the T-tool and its mating slot in the claw. This interference was then eliminated by reslanting the pivot slot to better match the claw's rotational geometry. Re-bench testing verified that the interference had been eliminated. This design change is reflected in the as-built drawings.

PRELIMINARY FIELD TESTING

The finished prototype was then slated for testing on a Bureau crawler-tractor equipped with a backhoe boom. This required the design of a mounting bracket so that the claw-hammer assembly could be mounted in place of the backhoe bucket. Figure 7 shows the claw hammer mounted to the backhoe boom.

Hydraulic power for the claw hammer was obtained by tapping into the existing boom's hydraulics. A flow control valve was added to prioritize the hydraulic supply flow to the boom and claw-hammer assembly. The two hydraulic control valves for the claw-hammer assembly received higher priority while the bypass flow was directed to the boom control valves. This temporary hydraulic modification was sufficient to allow limited testing of the claw hammer while maneuvering it with the boom. Figure 8 shows the hydraulic control circuit for the claw hammer assembly.

The claw hammer was tested for function of the individual hammering and prying modes against both concrete blocks and quartzite boulders. This



FIGURE 6. Hydraulic Bench Testing Arrangement

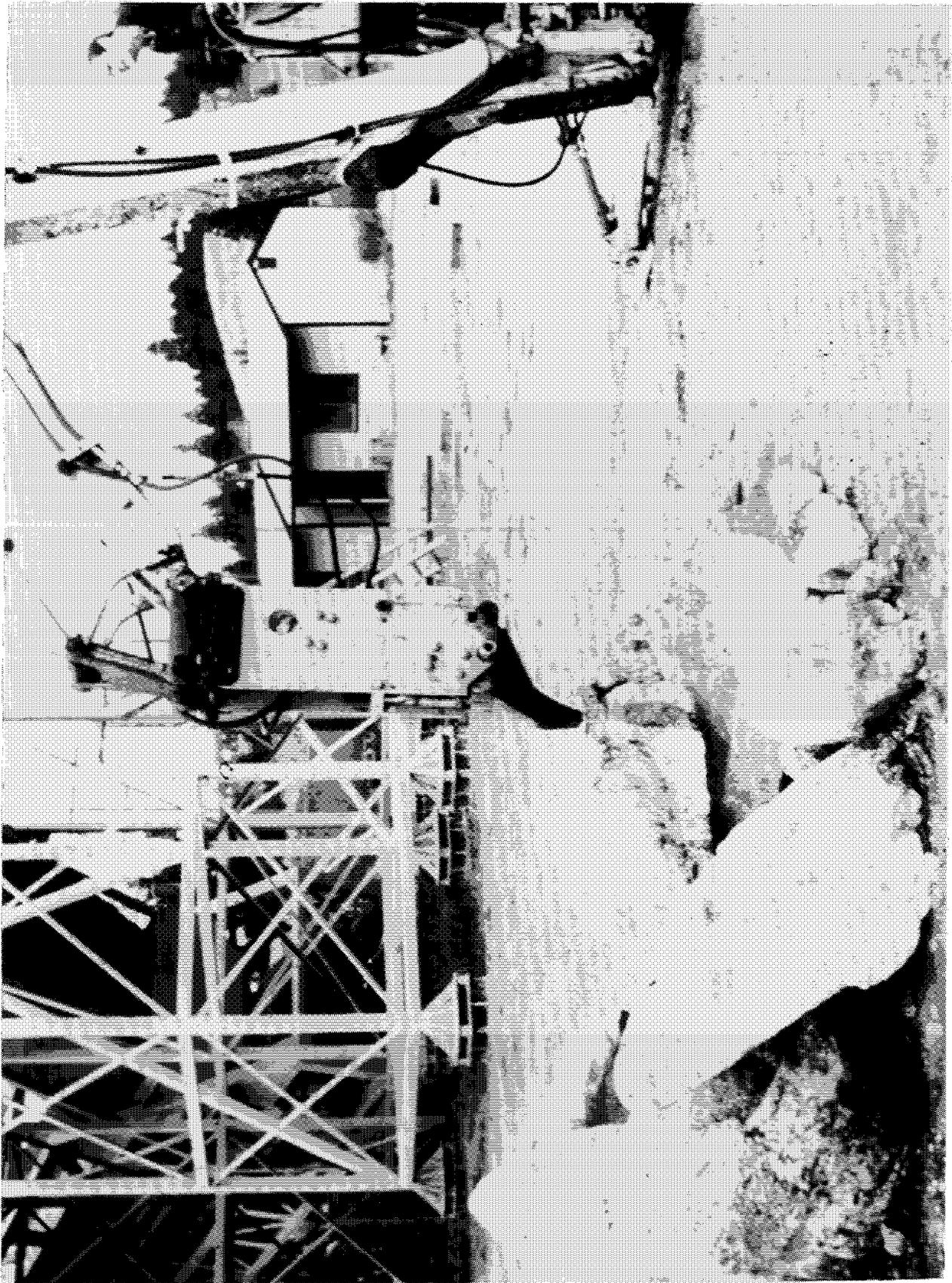


FIGURE 7. Claw Hammer Field Testing with Quartzite Boulders

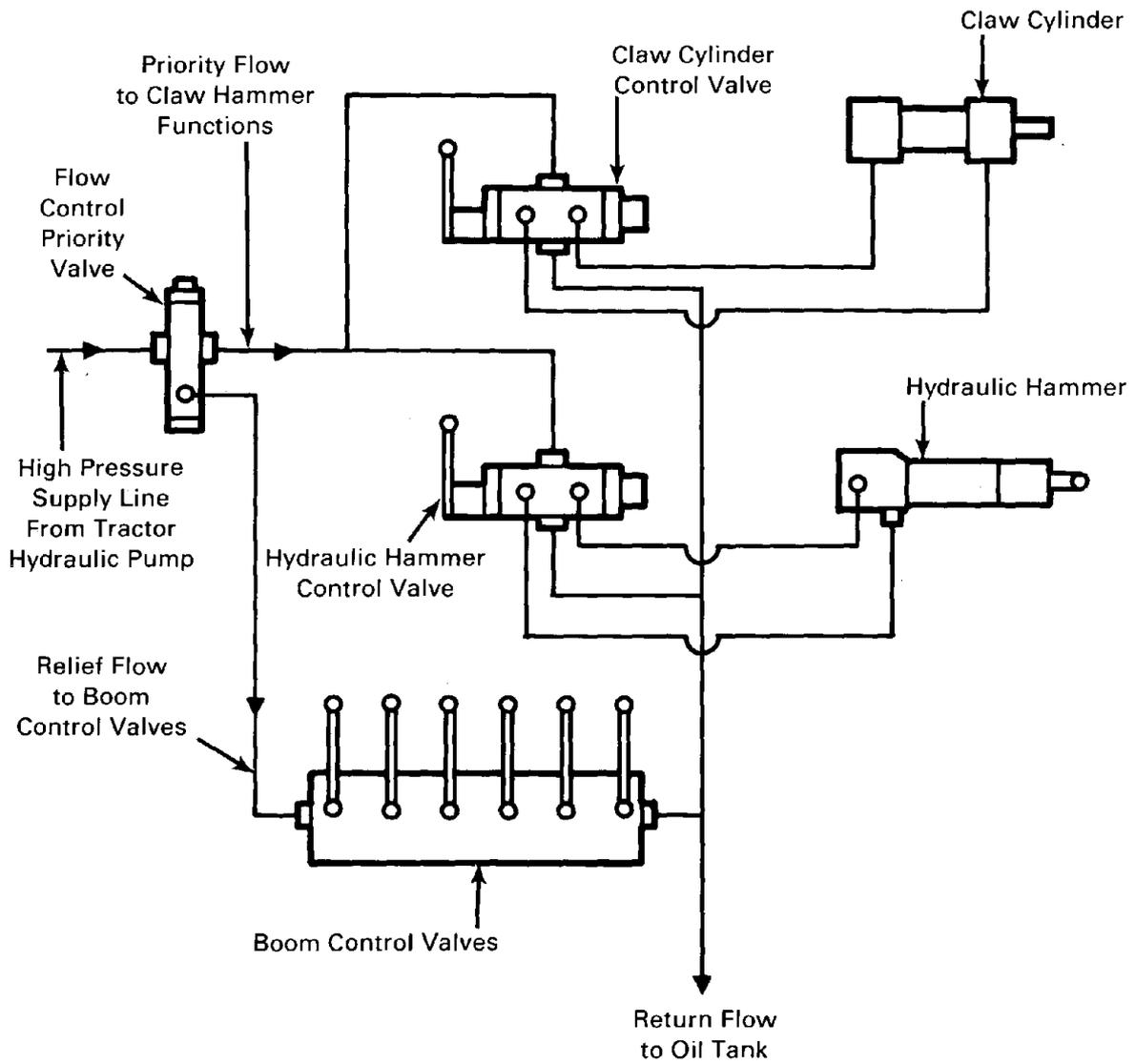


FIGURE 8. Claw Hammer Hydraulic Control Circuit

limited testing, exemplified in Figure 7, demonstrated the potential of the combination tool. The assembly was able to hammer the claw into solid rock and to pry off chunks that had been loosened by the hammering.

One major problem did arise during the early testing: the T-tool broke at the T-intersection. Subsequent investigation revealed breakage was design-caused. The original T-tool design called for an abrupt change in the cross-sectional geometry at the T-intersection. This change apparently led to a stress concentration problem. The problem was solved by redesigning the T-tool with generous fillets at the intersection to reduce the stress concentration factor. The redesigned T-tool did not break despite the considerable amount of testing performed after the problem was discovered.

CONCLUSIONS

Based on the limited testing performed, the combination claw-hammer tool concept appears viable. Early testing verifies that the functions of both a ripper scaler and a hammer-powered scaler can be successfully combined. Further testing in actual scaling conditions will be necessary to fully assess the device's capability.

The prototype appears to be easy to maintain. The design was purposely kept simple and robust to make the device acceptable in the mining environment. It can be lubricated without any disassembly. The two primary wear items, the claw and the T-tool, can be replaced quickly and with a minimum of tools. If the need arises, the entire unit can be disassembled in approximately 15 minutes using common hand tools. In fact, the tool's simplicity and ease of maintenance should help promote its potential for underground usage.

RECOMMENDATIONS

Battelle recommends that the prototype claw-hammer assembly be fully tested in a mining environment, preferably mounted on a fully articulated boom. Factors needing assessment include 1) operator acceptance, 2) visibility, 3) reliability, 4) maintainability, and 5) most important, overall scaling capability in various rock formations requiring both scaling functions. The assembly's performance with respect to these factors then should be compared to that of other scaling methods to permit an assessment of the claw-hammer's ultimate usefulness.

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