

completed. This included not alone the sinking of the shaft, but the heavy steel sets were placed in position, the concrete slab-lathing was put in place for the entire distance, also the back-runners. The magnitude of the work may be better understood when it is realized that 24,600 cu. ft. of rock were broken and hoisted to the surface, and the labour of placing the shaft equipment, consisting of two skip roads, one cage road, ladderway, pipe compartment, counter balance and back-runners, completing a modern five-compartment shaft, was all performed in 26 days. Each piece of concrete slab-lathing weighed 130 lbs. and the steel sets were made of heavy material. Six Jackhammers were used to sink the shaft.

The East Butte Copper Mining Co. is sinking a shaft through a hard granite formation with two Jackhammers, from the 1,200-ft. level to the 1,800-ft. level, and reports show that from Jan. 20 to Feb. 15 of the present year 110 ft. of shaft were driven, including timbering. During this period they lost 11 shifts due to outside causes, no work whatever being done. Here an average of 28 holes was drilled per shift, 8 cuts 9 ft. deep, 8 lifters 6 ft. deep, 6 back holes 6 ft. deep and 6 end holes 6 ft. deep. Occasionally as high as 33 holes were drilled. The average net drilling time was 5 hrs. This gives a total hole footage per shift of 192 ft., or 96 ft. per drill, an average of 19.5 ft. per drill per hour. The previous best progress, made with heavy tripod drills, was 60 ft. in one month. Size of shaft, 19 ft. 6 in. by 6 ft. 10 in.

J. A. McIlwee, the contractor who drove the Laramie-Poudre tunnel, is sinking a shaft for the Silver King Consolidated mine, Park City, Utah. This is a three-compartment shaft and is being driven a distance of 500 ft. from the 1,300-ft. to the 1,800-ft. level. The work began March 22, with four Jackhammer drills, two on each side of the shaft; four drillers were employed. A great many delays and drawbacks were experienced, mainly on account of water. Some boiler difficulties were incurred, which caused a delay of four days in April. Notwithstanding this, 105 ft. of actual sinking or 95 ft. of completed and timbered shaft have been accomplished. Based on the number of days actually at work sinking, this is a progress of about 5 ft. per day. Holes were drilled 5 ft. deep, the usual time employed being 10.5 min. per hole. The best time made in drilling was 33 holes 5 ft. deep, with 6-ft. cut holes, in 2 hrs. 45 min.; three shifts, each shift gang doing the drilling, mucking, and timbering.

Bench or foot-wall work has heretofore been done with large drills, employing from two to three men per drill. Deep holes of large diameter have been drilled, but during recent years the hammer type, both in the stoper and in the Jackhammer, has replaced the heavier machines for this class of work. In one of the Lake Superior copper mines recent extensive tests have shown the following figures:

Type of Drill	Tons per man per shift	Mining Cost per ton.
Stoper	13	\$0.41
Piston	12	0.54
Jackhammer	38	0.12

No overhead charges are included in the above figures of cost, nor are charges for air included. This effective saving by the use of stoper drills over the heavier tripod type, and the still further saving by the use of Jackhammers, cannot be maintained in all classes of work. In this particular case the bench or foot-wall afforded the best opportunity for the use of these little Jackhammer drills.

An analysis of the drill situation, in the iron fields of Lake Superior, indicates that four types of drills are

necessary for the economical extraction of the ore, their relative proportion being about as follows:

	Per cent.
1. Mounted hammer drill	20
2. Stope drills	20
3. Jackhammer or sinking drills	10
4. Light piston drill	50

There will always remain a small percentage of drilling for which the two-man piston drill will still be the favorite. An instance is the operation of the Soudan mine at Tower, where the rock encountered is very hard; in fact, it is characterized as the hardest in the United States.

At this time the ore is very hard and dry, and the chief problem is not so much one to be met by the use of some particular type of drill, but rather one of getting the steel to stand, as the bits will not hold in this rock. Records show that as many as 80 starters have been used, with a 3.25-in. machine, to drill a hole 6 in. in depth. Light one-man drills have been tried in this formation, but without success.

In the hematite mines of Lake Superior the light reciprocating mining drill is generally used for the actual breaking of probably 90 per cent. of the ore which requires drilling (hand-auger ground excepted). In this class of work the service required of the drill is light, the ground being classed as very soft drilling, but of such a character as to bring it under the classification of "too hard drilling" for hand augers.

In the city of Pittsburgh, Jackhammers are being employed for driving an 8 by 12 ft. sewer tunnel, 1,200 ft. long. The formation is a hard slate and shale with a decomposed rock top. Single cap timbers are installed and it is necessary to use fore-poling to hold the top. Two drills are installed in the heading, drilling eight 3-ft. holes, with a single steel to the hole. The average drilling speed is 12 in. per minute. Owing to the bad top and the fact that the tunnel passes under two bridge piers and the Pennsylvania Railroad tracks, the shooting is necessarily light; about 2.5 ft. are pulled at each round. Ten feet of completely timbered heading is the advance per day of two shifts.

The following is a record of work done with Jackhammers in the excavation for the Grand Central Station, New York City:

Month.	Hours drilled.	Total linear ft. drilled.	Average ft. drilled per hr.
Sept. 22 to 29	60	950	15 5/6
Oct. 1 to 31	255	4,256	16.65
Nov. 1 to 5	48	800	16 2/3
	363	6,006	16.5

Cost for repairs (2 pawls, 50c. each), \$1, or about 1 2/3c. per 100 ft. drilled.

Air pressure, 70 to 90 lbs.

Holes drilled, 4 to 10 ft. in hard New York mica schist.

In the lead mines in southeast Missouri they have heretofore drilled the down-holes in the stopes with the large type of two-man drill. Since the Jackhammer has been introduced in these mines the results obtained have been 60 to 80 ft. of 8-ft. holes per man per shift, while with the old system employing two men they were only able to drill 40 to 50 ft. of 8-ft. holes per shift. In many cases where the vein is exceedingly wide they drill 10-ft. holes as easily and readily as an 8-ft. hole can be drilled.

In the Oliver iron mines in Michigan the record is given as 57 stoper drills operated in the year 1912, with a total expense for repairs for the year of \$920.23, or \$16.14 per machine per year.