on one end, by means of which the tube is hammered down to near bed-rock. The steam is emitted from the tube horizontally through holes in the side, close to the point. A description of a thawing plant which the writer saw in operation may convey a more complete idea of the process. A 90 horse-power boiler supplied steam for eighty points, which were driven to an average depth of about fifteen feet on eight-foot centres. The points consisted of ⅜-inch and ¾-inch diameter iron pipes, with steel shoes. Steam was delivered to the points at an indicated pressure of twenty pounds. The points remained in the ground from two to three days. The operation kept five men shifting points and one man in the boiler-house.

After the foregoing outline of the frozen ground problem it may be well to continue with the description of the various mining methods. The first advance on the original placer mining by panning was the introduction of sluice-boxes, used wherever sufficient water was available. Following this came the introduction of machinery. Claims were worked by the open-cut, or by the drift and hoist method. The open-cut system merely entailed excavating to pay-sand, either by the hydraulic method or by thawing and removing the earth and sand by hand labor, by steam shovel or by a bucket elevator.

The drift method consists of sinking a mine shaft in the usual way and "drifting" or running underground cuts,

Fig. 4.—Operating a Hydraulic Plant.

the sand, etc., being elevated as before and sluiced. These two methods, while improvements on the original process, were more or less crude. The cost of equipment in these cases never exceed about $8,000, and included the following: One 6-inch discharge centrifugal pump for elevating water for sluicing; one 40 or 50 horse-power boiler, with an 8 or 10 horse-power engine, working a hoist and self-dumping bucket; a small pump of 3-inch discharge and 1-inch nozzle, used for thawing, or else a set of steam points. Such a plant has a capacity of about fifty cubic yards of material sluiced per day. Of recent years mining has been attempted on a much larger scale. In general, the three systems employed by large companies are:—

(a) Dredges for creeks and valleys.
(b) Hydraulicking for the hillsides.
(c) Hydraulic and mechanical elevators.

The Dredging System.

Externally, a dredge (see Fig. 1) is similar in appearance to the usual type, except that instead of the familiar arm and dipper the excavating is done by a series of dippers connected to a continuous chain belt arrangement known as a "bucket-line" (see Fig. 2).

The dredge is floated primarily in a creek. The buckets are caused to dig from the bottom of the creek to near bed-rock, where pay gravel is found, and excavation is gradually carried into the bank. Thus the dredge literally "eats its way," forming its own channel. The gold-bearing sand and gravel is mechanically sluiced inside the dredge, and the refuse, known as the "tailings," is carried out of the back of the dredge by a conveyor or "stacker" (Fig. 3).

The main points in the distribution are to get the conveyor long enough to stack the coarse material to a height sufficiently great, and far enough behind the dredge, so that it will not run back; also, the fine tailings must leave the dredge at an elevation which will ensure storage room.

The disadvantages of this system are, first, that the place of excavation is not visible; and second, the dredge only operates to bed-rock. Frequently gold is found four or five feet down in the rock crevices, jointage and bedding planes.

It will be seen from the system of dredging briefly described that the original course of a stream does not limit the field of working of the gold-dredge, since its operation permits of excavating anywhere in the valley, or, technically speaking, on the "benches" contiguous to the river on which the dredge was originally floated. In this lies one of the chief advantages. A most concise description of a "gold-ship," to use popular parlance, is given by Mr. F. W. Griffin, M.E., of San Francisco, Cal.:—

"The dredge of the present day is the endless chain elevator type. An endless chain of buckets is carried on rollers resting on a steel ladder. The upper end of this ladder is hinged on a gantry frame, about twenty feet above the deck of the dredge. The lower end of the ladder is suspended by cables, which pass over sheaves to a drum on a winch, so that the ladder may be raised or lowered to feed the buckets. The buckets pass over tumblers at the upper and lower ends of the ladder. The power to drive the bucket line is applied at the upper tumbler through gears. The material as excavated by the buckets is dumped into a hopper, and from this hopper is fed to revolving or shaking screens. Water under pressure is forced from spray pipes over the screens on to the travelling gravel. The gold-bearing material passes through the screens into a distributor, which feeds this material and water to tables provided with riffles. These tables in turn discharge into side or tail sluices, which deposit the fine tailings well behind the dredge. The coarse tailings, after being washed on the screens, pass from the screens to a conveyor, which carries these tailings 30 to 50 feet behind the dredge and stacks them 20 to 30 feet high."

The capacities of dredges vary from 40,000 to 70,000 cubic yards per month, figured on the basis of a 20-hour day. This limit of size is considered economical, although 100,000 yards have been handled. This rated horse-power of a dredge approximately from 185 to 260, although no definite law can be established for accurately determining this requirement, owing to the continual occurrence of sudden over-loads, due to the buckets striking heavy boulders, etc. Steam has been used as a driving power, but a modern equipment will include an electric installation for running the dredges. In this case it will readily be seen that the motor must be designed for variable speed.

Figs. 1, 2, and 3 illustrate a Bucyrus dredge, made in South Milwaukee. The actual capacity varies from 2,000 to 2,500 cubic yards per 20-hour day. The rated horse-power is 250, distributed as follows:—

(a) Bucket line, 100.

(b) Cenrifugal pump, used in elevating water for sluicing, 75.

(c) The stacker, 25.

(d) The rotary screen, 30, (used for preliminary sifting of large stones).

The remaining 15 horse-power is utilized in shifting the bucket line and in sundry small requirements. The gold, sand, gravel and water enters the dredge by the bucket-line and receives a preliminary sifting in the rotary screen, in which the meshes are ¼-inch diameter on ½-inch centres. Subsequently, the remaining slurry of gold and sand is run over a series of metal sluices, the gold being deposited between the riffles and the sand being carried out by the stacker.