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PLACER MINING METHODS IN THE FAIRBANKS DISTRICT

A THESIS

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Introduction.

Fairbanks, Alaska, is the center of an immense placer mining district. A large percentage of the creeks in all directions contain gold in paying quantities. The gold in the different creeks does not occur at the same depth from the surface and this has led to the development of many different types of mining.

It is the purpose of this thesis to present these different methods and costs where they may be given. A brief history of the camp has been included in this paper. The old timers of this district are rapidly passing on and it is thought well to put the real history of the discovery of the camp down on paper where it will be retained.

Acknowledgements.

Much of the information set forth in this thesis has been obtained from actual field experience, by means of interviews with men who have had early experience in this section and from information derived in making plant layouts for different corporations.

The pipe selection chart and automatic gates were copied from Bureau of Mines Information Circulars. The different prints showing bracing methods and water flows are a part of the information given to students in the

author's placer mining class. These charts have proven of great value to new camps starting up in other sections of Alaska.

Fairbanks District.

The Fairbanks district of Alaska comprises an area of approximately six hundred and ninety square miles and extends from west longitude 148° 05' to longitude 147° 05' and from north latitude 64° 50' to latitude 65° 10'.

Immediately following the discovery of gold on Pedro Creek by Felix Pedro in the summer of 1902, this region was stampeded by gold seekers from Dawson and the Forty mile country. The "new diggings" were deeply buried and since "deep ground" was beyond the experience of most, the greater number of the gold seekers left Fairbanks for other districts that appeared more favorable to them. Further discoveries incited two more stampedes before the new camp finally became recognized as a good thing.

In 1904 the camp took its place as one of the principal gold producers of Alaska. It reached its peak under the mining methods in use at that time in 1909 after which date the production began to diminish. This period marks the transition from the easily-worked, shallow ground to the rich, but deeper drift ground.

By 1912 total production of gold had reached the sum of $57,460,000. The next thirteen years saw it climb up to $73,850,000, while now, 1936, it has a grand total of at least over $100,000,000 and by a very conservative estimate there is still that amount waiting to be mined.

The rapid decline in the gold production of the Fairbanks district during the early years of the war was a decline in production common to all gold mining camps. The rising prices of supplies during the period of the World War is almost universally given by men mining during that period as the cause of this production slump. While costs were excessive and marginal producers were forced to cease operations for that reason, this period was disastrous to the Fairbanks district only as a culmination of a series of other causes. The rich, shallow deposits and the rich and deeper deposits suitable to be drift mined had supposedly been exhausted. Methods previously employed were too costly to be applied to low grade ground that remained. Large scale operations cheaply conducted could be the only salvation of the remaining deposits. The costliest item in mining in the North is the necessity of thawing frozen gravels. While steam, hot water and stripping practice had sufficed for small scale operations of previous years, they were far too costly to use on low grade gravels.

In the Nome dredging fields the use of water at natural temperatures as a thawing agent was tried and proved to be successful. This development provided a cheap means of thawing ground on a large scale and solved the problem of mining low grade deposits. The Fairbanks district was rejuvenated, an immense project involving a very large outlay of capital was instituted and the district has again come to the front and is attracting attention by reason of its prospective future as a producer of placer gold. The increase in the price of gold has also helped a great deal in making sub-marginal ground mineable. It is really surprising the amount of new deep ground that is discovered in the Fairbanks district each year by the use of churn drills. See Figs. 1 and 2.

Historical Sketch.

During the summer of 1898 a prospector, Felix Pedro, accompanied a young engineer on a trip out of the Fortymile region and down the Tanana. A clear water tributary to the Tanana was explored and on a branch of this tributary Pedro panned the bars for placer gold while the engineer examined a wide quartz vein showing in the walls of the valley. Here Pedro found prospects which appeared to him to be good. He wished to remain on the creek and prospect, but with the approach of winter the two were forced to make their way over the mountains and back to the Fortymile region. Landmarks such as the appearance of the junction of the streams, the presence of an Indian village, the band of white quartz and the location of the boat, which they cached together with a portion of their outfit at the head of the creek, Pedro fixed in his mind to use as aids to assist him in finding the creek at some later date.

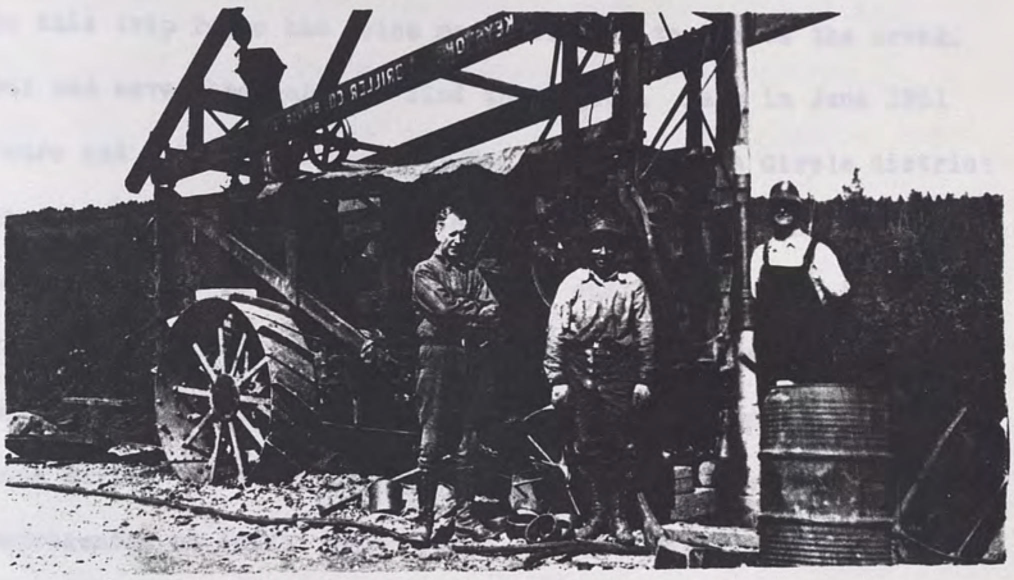


Fig. 1

Keystone drill spudding in a prospect hole.

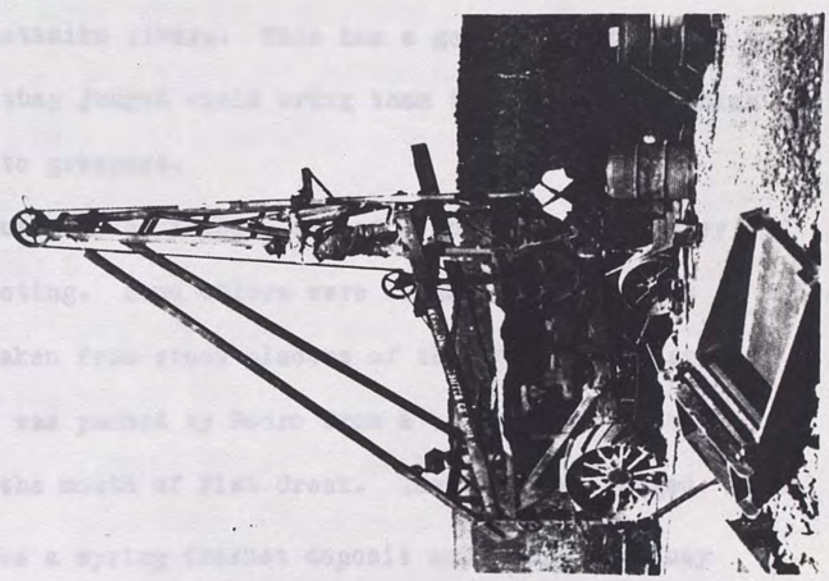


Fig. 2

Crew of 3 men. Driller,Panner and Fireman.
Note rocker in foreground used for washing gravel.

The return was delayed, and it was not until 1901 that Tom Gilmore joined Pedro on a prospecting trip in search for the creek on which Pedro had discovered gold in 1898. Prior to this trip Pedro had twice made attempts to locate the creek, but had never been able to find the region. Late in June 1901 Pedro and Gilmore started from Eagle Creek in the Circle district carrying with them a complete outfit exclusive of tents. They had two horses on which to pack their outfit which, it is judged, puts the weight at about 400 lbs. This outfit was, of necessity, mostly food since very little "living off the country" can be done during the summer months in Alaska. At the utmost this represented an outfit which would last two men about two months.

The partners started out in a southwesterly direction which they intended to follow as far as the Tanana River. A few days out, the compass by which they set their course was lost and they then decided to follow the ridge between the Chena and Chatanika rivers. This has a general southwesterly trend which they judged would bring them to the area in which they wished to prospect.

In about four days they reached Fish Creek where they began prospecting. Some colors were found, and the first gold to be taken from creek placers of the Fairbanks district by white man was panned by Pedro from a bar situated about a mile from the mouth of Fish Creek. The partners judged this bar to be a spring freshet deposit and therefore they did not consider the find a very good indication of valuable placer deposits on the creek. The mere fact that gold had been found, however, served to encourage them.

Leaving Fish Creek they crossed over the divide (Pedro climbing the top of Pedro Dome) and continued downstream along Fox Gulch to a point about a mile below the present site of Fox. Here a promising showing of gold was found by panning the river bars. This widespread occurence of colors over the area served to indicate to them something of the vast extent of the mineralized area through which they were passing. Pedro was firm, however, in his determination to reach his former discovery so they did no further prospecting at that time in the Fairbanks district.

Following the high divide from Circle to Fish Creek, the party had encountered fairly easy going. The ridge was for the greater part above timber line and fairly dry. In following the creek from Fox down it was difficult traveling. The trail had to be chopped out for the horses to get through and the wet swamps were infested with hordes of mosquitoes. Once in crossing Goldstream one of the horses was almost lost.

Following Goldstream for about thirty miles they reached the foot of Ester Dome about a month after leaving Eagle Creek. Here a party of four men with pack horses joined them. These men had followed Pedro and Gilmore out from Eagle Creek, believing that the partners were enroute to a "find."

Ordinarily Pedro and Gilmore had no wish for company, but now they were much pleased with the addition to their party. Provisions were running low and a new supply was welcome. In addition, the trail had to be cut for every foot of the way and streams and swampy portions bridged. This was difficult, tedious and slow work for two men while with six men the progress was fairly rapid.

Swinging off Goldstream to the left, the party climbed to the top of Ester Dome with the idea that from that point they could survey the country and make plans for further progress. While they were on the Dome they sighted a boat coming slowly up the Chena Slough. With the aid of field glasses the name of her pilot house -Lavelle Young- was readable. This boat they recognized as being a trading boat belonging to E. T. Barnette. As they watched her she tied up at a bend in the slough and the crew made preparations for an extended stop.

The prospectors needed provisions badly, and here was a precious opportunity to obtain some. They immediately set about laying out a course over the flats to the boat. Having determined on a course of travel, the party came down from Ester Dome and at nightfall camped on Ester Creek.

For some time heavy rains had been a daily occurence, and the swamps were almost impassable. After about three days hard going, building a foundation for the horses to walk on and bridging cuts and gullies, they reached a point on Noye's Slough, about two miles from where the Lavelle Young was tied. From this point Pedro and another man went forward on foot. They had provisions landed on the north side of the slough and the entire party then assisted in bringing the supplies to the base camp.

At this point it may not be diverging too much to tell of the founding of Fairbanks.

In the spring of 1901 E. T. Barnette started from St. Michael in the steamer Lavelle Young to start a trading post at Rapids at the junction of the Tanana and Delta rivers. Unable to reach his destination, he returned to the mouth of Chena Slough and followed up the slough until he reached the present site of Fairbanks, where low water forced him to tie up. Here he established an Indian trading post which was first called Barnette Post and later Fairbanks.

It may also be noted that in crossing Ester Creek the party passed over and camped on what has proved to be probably the richest shallow ground in the Fairbanks district. Millions of dollars were passed over by them in one day.

From their camp on Noye's Slough, Pedro and his party traveled approximately seventy miles in a southeasterly direction. Late August found them on a creek which Pedro believed to be his "lost creek." True, the landmarks were missing or not very clear; the Tanana had changed its course, hence the junction of the tributary was much changed in its appearance and the Indians had quitted the country leaving no trace. The boat and supplies left here in '98 were never found. Despite his uncertainty, he believed it to be the same creek, and it was named '98 Creek" in memory of its supposed discovery.

The entire party staked on the creek and then, since their provisions were nearly gone and winter was close to them, Pedro, accompanied by three of the others, headed back to Circle to get a substantial outfit.

The remaining two of the party took their horses and traveled down the Tanana to Barnette Post. The party returning to Circle followed the high ranges and did not touch at Barnette Post.

Pedro and his three companions experienced many difficulties in their trip across to Circle. Winter was coming on and the fall rains had set in, rivers had to be forded in cold and disagreeable weather while snow was encountered in the upper ranges. All but one of the horses played out before Circle was reached. The tired animals were left in good pasturage, and the party went on with one horse and a dog to pack the food and equipment. The dog strayed off and lost his pack which contained what little food they had left. For days before they had been passing through herds of Caribou, but they had kept their packs as light as possible. Now not even stragglers were to be seen. This new disaster left them with no food except a little flour and salt. Tired and hungry, they finally reached Eagle Creek having had nothing but "doughgobs" to eat for three days travel.

As soon as the party landed in Circle the news that Pedro had found his lost creek spread and about nine men, including Gilmore and Pedro, went back to '98 Creek to prospect throughout the winter of 1901. This time they had a full outfit including stoves, tents, and an adequate supply of food. Dogs were used for transport.

Arriving on '98 Creek, the whole party started sinking holes. Some eight or ten holes were sunk to bedrock. Colors were found from top to bottom of the holes, but the final results were far from encouraging. Everyone was discouraged with the new region, the winter was half gone and the outfits were exhausted. The next question was naturally "where to?" Lengthy and heated discussions were held regarding the possibility of gold in this region. Gilmore and Pedro were anxious that the others accompany them back to the creek (about a mile below Fox) where they had panned gold early in the preceding summer, but the others, distrustful of Pedro because of their failure to find gold on '98 Creek, refused to accompany him on a wild man's chase, and returned to Circle where they dubbed Pedro the "old witch."

Pedro and Gilmore returned to Barnette Post and spent all but a few dollars of their money in replenishing their outfits.

Leaving Barnette Post they followed up the Chena River to the mouth of the Little Chena River, thence up that stream past the mouth of Fish Creek, where they had found their first colors the summer before, to the extreme head of the creek. From here they crossed the divide into what was called Quartz Creek. There they put down five holes. In each of these they were drowned out. None went down to bedrock. Abandoning Quartz Creek they returned over the divide to the Little Chena and followed it downstream to the mouth of Fish Creek.

From here they intended going up Fairbanks Creek to prospect. Had they done so they would have saved much discouragement, useless work and wasted time. One fact, seemingly slight, kept them from following out their plans. At the mouth of Fairbanks Creek a tribe of Indians was camped and hunting. These Indians were not friendly and did not relish the idea of the white man entering their hunting grounds for the remainder of the winter. Before the white men left their camp at the mouth of Fish Creek one of the Indian children, while running on snowshoes, fell and ran a willow in his thigh. At the sight of blood the Indians became excited and begged the white men to "fix em up." Pedro acted as medicine man and washed the wound with Cuticura Soap, covered it with salve and wrapped it with dishclothes. This act of friendship completed, the Indians became confidential and told Pedro to "go up next creek; White man dig, get plenty gold." Pedro suspected that the Indians' sudden friendship was merely a means of getting rid of him, but he did not wish to antagonize them. Although Fairbanks Creek looked better to him, "the next creek" which was afterwards named Bear Creek, looked about as good and there was a faint possibility that the Indians' tale of "plenty much gold" might have a grain of truth in it. The Indians direction was accordingly followed.

About two miles above the mouth of Bear Creek they made camp and started work. Two holes were started, but only one was put through to bedrock which was about twenty one feet below the surface. This entailed about twenty feet of thawing with wood fires. Colors were found scattered from top to bottom of the hole. Almost the entire dump was panned, but the whole yielded only about $2.50. No claims were staked on that creek. During early spring a big bear was killed and her two cubs captured, hence the name "Bear Creek."

Spring found the prospectors with little of their outfit left and one bearskin and $2.50 in gold dust to represent their winter's work. Pooling the few dollars that they had left with the addition of whatever the bearskin would bring and the $2.50 in gold dust, there would be just enough money to replenish their outfit at Barnette Post and give one man enough to keep him going during the summer. This they decided to do. Pedro was to stay and prospect and Gilmore was to return to Circle and work to earn enough money to buy an outfit for the following winter.

During the later part of August of that summer (1902), Ed Quinn came from Fairbanks district into Circle. He had seen Pedro and had helped him prospect. Pedro had sent word by him to Gilmore that he had made a strike on Pedro Creek and that the new country looked pretty good.

This news started a big stampede. All the men who had been with Pedro on '98 Creek and who doubted and refused to follow him into the new country when he wanted help to prospect it, now flocked into his strike. The new country was found to be rich and large enough to give all of them good ground.

Men came from Dawson and, while some of them scoffed at the new camp, as did one "pardner," "There's more gold in my mouth than there is in that whole country," a few of them remained to work ground and introduced the methods and appliances that had been evolved in the Dawson camp.

Towns such as Cleary and Chatanika seemed to spring up out of nothing. Fairbanks grew from a tiny trading post with a small trading boat tied in front of it to a bustling mining camp with river boats busily plying the river bringing in food and machinery -- and always more gold seekers. It was a mining camp, a big one, the last big stampede to the last big camp Alaska has seen. The name that stands behind all this is the name of the man who had faith enough and perseverance enough to keep at the hard game of prospecting until his faith was rewarded. Felix Pedro.

DESCRIPTION OF PHYSICAL FEATURES

Topography and Geology.

Topographically the Fairbanks district lies in two divisions; the Tanana lowlands and the Tanana uplands. The uplands lie toward the north from the lowlands and are the stumps of an old mountain system which has been deeply eroded. This district has not been glaciated, erosion having been due to stream action alone and the accordant summits of the erosional stumps are easily discernable from any commanding elevation. The low, rolling hills have an elevation seldom exceeding 2000 feet and, except from the very tops, are covered with a heavy mantle of weathered soil. It is in this part of the district that the active placer mines are found. Due to the erosional history of this country, deep placer is the rule.

All the placer deposits found in the Fairbanks district are frozen and consist of muck, gravels, sands, peat and other vegetation, volcanic ash and ice. The muck is very rich in fossil remains of the Pleistocene age. The summer of 1932 I spent collecting these remains for the American Museum of Natural History of New York City. Numerous specimens were found of super-bison, horse, mammoth, rodents, what is believed to be the skull of a saber tooth tiger and a new subspecies of the Mastodon family which was given the name, Mastodon americanus alaskensis. Another specimen worth mentioning is a huge tusk measuring 12 feet, 10 inches on the outer curve and having a weight of over 300 pounds. This tusk was broken off where it joined the jaw and had a circumference at that point of 24 inches, as far as I can ascertain this is the largest tusk on record.

Except for thickness, the gold-bearing gravels and their overburden of ice and frozen muck, gravels, sand, peat and volcanic ash are more or less alike. A generalized description of one placer camp in the Fairbanks region would do for most of the others. A detailed vertical section from one locality, however, cannot be duplicated any other place. In general, the deposits are in the following sequences: bedrock usually of Birch Creek schist of pre-Cambrain age; on this are frozen gold-gravels, then frozen muck containing beds of gravels, sand, peat, and ash. Interspersed throughout the deposits are beds of ice of considerable thickness and of great areal extent, lying beneath a great percentage of the muck. The material above the gold-gravels, taken as a whole, are stratified, though poorly so. The muck itself, for the most part, is unstratified. The various beds have various altitudes ranging from horizontal to vertical. Areally, the deposits change suddenly, the muck giving way to any of the phases mentioned.

The gold-gravels underlying the muck are usually separated rather sharply, although this isn't a fixed rule as in some localities, they seem to merge gradually. The gravels in the Fairbanks district range from a few feet in thickness to over a hundred. The same is true of the deposits of muck. Some are now being removed, having a depth of over a 150 feet.

Climate.

The summer season in the Fairbanks district lasts for about three months. The water starts to run about the middle of May and will stop the latter part of August or the first part of September. This shortness of season was a very serious handicap to the early miners, particularly to open-cut miners. Since dredges have been installed in the district, they have lengthened the mining season to as high as 270 days, while a season of about five months is considered very good for a dragline operation.

During the winter the low temperature freezes the ground for several feet and this frost is often partly retained by the overlying moss throughout the short summer. Glaciers form in many of the gulches during the winter and are a great hinderance to transportation as well as in mining during the early summer.

Rainfall is not heavy in the district, the annual precipitation amounting to less than 12 inches. This lack of water was one of the most serious handicaps confronting the early miners. Now that diesel engines are being used in the district it is not so important.

Supply routes.

Until the Alaska Railroad was completed into the Fairbanks district, during 1923, the seasons controlled the mode of transportation in interior Alaska. During the summers the rivers formed the arteries of commerce, the Yukon and its great tributary, the Tanana, being the supply routes into this vast area. During this short period the traders imported the huge stocks of supplies and stored them at convenient points along the rivers. During the winter the principal means of transportation was by dog and horse teams. Prospectors then outfitted and moved their supplies into the area that they planned to work the following summer.

The Fairbanks district is situated in an extremely unfortunate location for easy transportation. Located almost in the center of interior Alaska, the Yukon and its tributary, the Tanana, pass on either side. The Yukon flows 160 miles to the northward. The Tanana flows through the lowlands bordering the south side of the district. The distance from it to the producing areas is not great but the river is bordered on that side by numerous sloughs and swamps which are almost impassable. The town of Fairbanks is established on one of these, Chena Slough, and, while it is close to the gold bearing area, the river boats could only reach it during high water periods. Shortly after its founding, a rival town, Chena, was established at the confluence of the Tanana River and Chena Slough, some 12 miles down stream from Fairbanks.

In 1905 Falco Joslin built a narrow gauge railroad between these towns and later this was extended northward across the producing areas.

Another route reaching the district was by the Valdez Trail, 372 miles long. Originating at Valdez on Prince William Sound the Trail ascends the Coast Range, crosses the broad uplands between that and the Alaska Range, and through that range and over the Tanana lowlands to Fairbanks. During the winter months this trail was the principal route of entry into the district. Over it the necessary foodstuff and mail were freighted. Starting as a trail for dogs it developed into a road for horse-drawn sleighs. Later the United States adopted it as a military highway which is now called the Richardson, after the Army man in charge of its building.

In the early days freight rates from the town of Fairbanks to the surrounding creeks were high. Roads were corduroy and were soft and had to follow the tops of the ridges in order to be passable at all. As an example of the freight rates paid during the early days the rate to Fairbanks Creek, a distance of 27 miles, was 27 cents per pound; now freight is hauled to the same place for 25 cents a ton mile during the open season.

MINING METHODS

In general the methods carried on in the Fairbanks district were, and are, much the same as those applied in other northern camps. Conditions are identical to those encountered in any other camp with the exceptions noted earlier in this thesis, i. e., the deep gravels and the difficult transportation conditions which confronted the Fairbanks operator. A classification of the methods of mining used in this district follows:

1. Open-cutting
   A method suitable to mining shallow deposits.
2. Hydraulicking
   A method suitable to mining shallow deposits where the supply of water is sufficiently great to operate the giants.
3. Drift mining.
   A method suitable to mining deep deposits where the gravel is frozen. This method reached its maximum development in the Fairbanks district.
4. Dredging.
   Dredging is the last stage in the progress of mining methods in the north and is the answer to the need of a cheap, large scale operation in the extraction of the gold from the deep low grade gravels which had no economic value under the old system of expensive mining methods.

"Ground sluicing" or the removal of muck is employed in all of the above methods except drift mining. The process of thawing is a necessary accompaniment of all types of mining where frozen gravels are excavated.

Ground Sluicing Methods.

"Ground sluicing" is a term that has been applied to a method used for the removal of the overburden. This method of stripping the gold-bearing gravels is common practice throughout Interior Alaska.

The moss and sod is removed by hand or by mechanical means before sluicing is started. This is accomplished by means of a tractor, a scraper such as a Bagley scraper, or by cutting with knives and removing by hand. The cost of each of these methods vary, depending upon the character and thickness of the moss and the feasibility of using mechanical means. On Candle Creek the cost of cutting and removing the moss by hand amounted to about one cent per square foot. At other places the cost has varied from one half to two and a half cents by hand methods. As a general rule the costs when using mechanical removal are cheaper than the above.

After the area has been stripped of moss and sod, a main drain is cut by using water under a head, or with creek water supplemented by blasting. The most successful drain that I have seen excavated was started by means of a large tractor and bulldozer. Modern excavating machinery is rapidly changing the older methods of mining. After the main drain has been cut, trenches are plowed at right angles to the main drain, and spaced about twenty feet apart. Water is then led to the head of these trenches and allowed to run through and out through the main drain. After the moss has been stripped the moss quickly thaws and the water deepens the trenches, cutting them down to grade with amazing rapidity. Fig. 6 illustrates a drain cut almost to gravel. The intervening muck pillars are thus exposed to the summer sun, and thaw and cave very readily. As the material caves it is taken into suspension by water and carried away. Often these muck walls are blasted to expedite the process. In some cases water under pressure from a hose or giant is forced into the cut, breaking up the material and keeping the drain clear. The best results are obtained if the drain is kept straightened out to procure the maximum grade, and if the curves which retard the velocity are avoided.

The minimum practical grade for stripping run-off water is probably .225%. Below this grade there is a rapid settling out of the suspended material and the cost of keeping the drain open is too great for ordinary mining.

Ground sluicing should be planned so that water may be applied to each cut at intervals best suited to the rate of thaw, which generally ranges from 3 to 6 hours.

In some places where a long narrow area is to be ground sluiced, the entire creek may be turned into a single longitudinal cut; when it has cut as deep and as wide as conditions will permit, the water is diverted by means of small temporary wing dams and shear-boards to undercut and cave the banks. This process is slow as frozen banks do not cave readily, and when they do they break off in large chunks which are very troublesome to handle.

Fig. 5
Giant setting on top of cone. Note height of cut and the way the material is removed from around the giant.

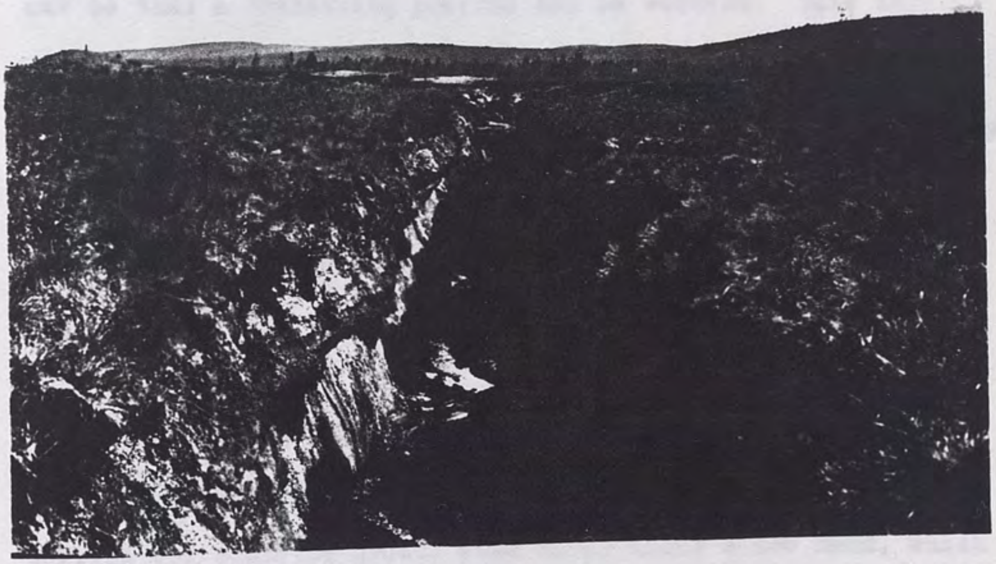


Fig. 6
A new drain cut through to bedrock. This drain has a depth of over 50 feet.

Where the water supply is too small for efficient, continuous use it is impounded and released at intervals by hand or automatically operated gates. The sudden rush or booming of the water down the cut greatly increases its carrying power.

Cost of Stripping.

The cost of stripping in this manner varies according to the characteristics of the ground and the scale of operations. A cost of from 5 to 10 cents per cubic yard is considered very reasonable. In many cases, however, where gravel from drift mining operations must also be removed, the cost will range from 20 to 35 cents per cubic yard and in many cases higher.

Use of Water Under Low Pressure.

Another type of ground sluicing is where water is used under a low head through giants or hoses. The plant is laid out so that a retreating program can be secured. This is particularly effective if the plant can be laid out so the area covered by each giant or hose can be worked intermittently, allowing sufficient time intervals for the area to thaw. The stripping water then quickly obtains a load of thawed muck and a high water duty is obtained.

Sprays.

Using the same general method, a new process has been derived for sluicing ground with water under a low head, which might be well termed the "spray method." In this case an

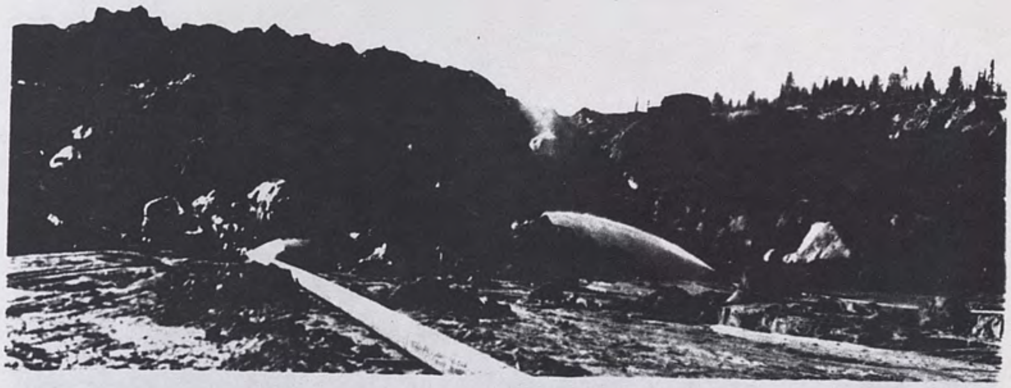


Fig. 3

2 giants working on a bank of muck 140 feet high.

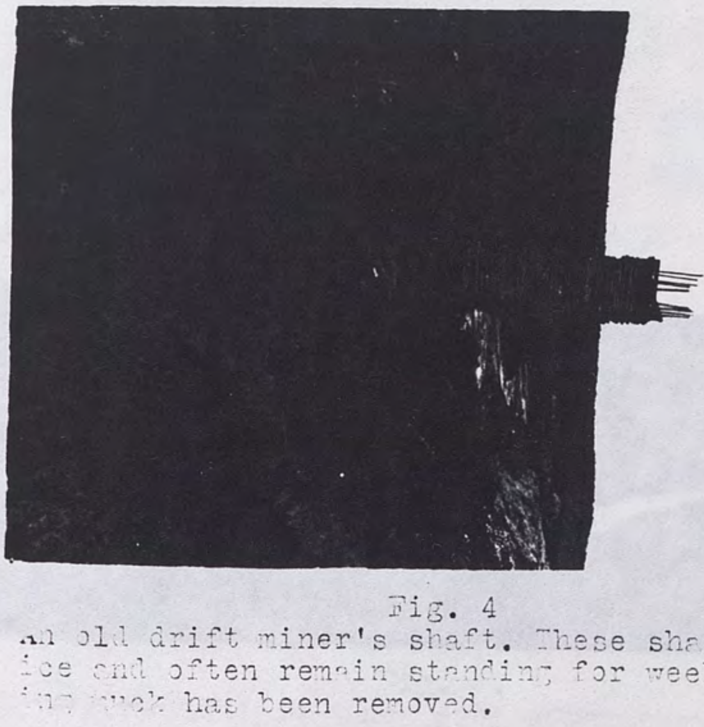


Fig. 4

An old drift miner's shaft. These shafts are filled with ice and often remain standing for weeks after the surrounding muck has been removed.

Fig. 7.
Small line take offs from the main line. Note valves on all take offs after they leave the main line.

Fig. 8.
Giants working on a new area after the moss has been removed.

excess of inexpensive water and a large amount of muck having a high ice content, provides a field for the development of the spray. The water, upon leaving the giant, is broken up into a fine spray which provides a uniform shower and keeps the area, being worked, continually wet. This breaking-up of the stream in the air gives it more opportunity to extract heat from the air so that in addition to having a transporting effect on the muck bed, it will also have a greater thawing effect.

Many experiments have been conducted to develop a suitable spray and consequently several different attachments have been used. The type that seems to serve the purpose the best is illustrated in Fig. 9. It is very simple and economical, and can be attached or removed from the giant very readily. It consists of a board hinged on a clamp around the spout of the giant, so that it can be turned down over the nozzel, flattening the stream. Two steel rows of welding rods 5/32 of an inch by 7 inches are set in a board at about 3/4 inch centers and staggered so that when the board is down they intercept the stream at almost right angles. This breaks the water up into a very fine spray which is effective in removing the muck.

Several experiments have been tried with moving sprays but as yet none have been developed which can compete with the fixed spray. The moving type has possibilities,however, and more work should be done to develop a successfull moving spray.

Fig. 10.
The writer operating a giant with a 150 lb. pressure.

Fig. 9.
Spray. Used for washing muck containing a large amount of ice.

Use of Water Under High Pressure.

The use of water under high pressure to remove muck and moss is a comparatively new method. The first instance of this type of sluicing on a large scale is the process used by the Fairbanks Exploration Co. The process was developed in this district and has proven to be probably the most economical method for removing muck so far devised.

General Layout.

The layout for removing the overburden from a piece of ground is goverened by the character of the ground, or whether it is covered with moss or tailings. Over much of the ground being worked at the present time are tailing piles left by the miners who first mined the ground by drift mining methods.

Probably the most successful way to discuss this problem is to divide the spacing of the giants into the headings: moss, tailings, and muck.

Moss.

The spacing for moss stripping is different than for muck or tailings. Stripping moss is more or less the same process for any type of ground so it can be generalized as follows: the best time to start moss-stripping is late in the season. By starting at this time advantage can be taken of the deep seasonal thaw, which is usually about three feet. This process also leaves the muck exposed so that muck stripping can be started in this area early the following season.

An ideal method of stripping moss is an advancing plan. A main line of about 20-inch slip-point is laid through the area to be stripped and 15-inch branch lines are driven from this at intervals of about 350 feet. Between each of these 15-inch lines, 10-inch lines are set. The giants advance, working at all times against a face of whatever the thaw amounts to. As the moss is stripped, a giant is left in place on the 15-inch line at about 450-foot intervals. After the moss stripping has been completed, the 10-inch lines are pulled out, leaving the giants on the 15-inch lines free to work the muck, each machine having a radius of about 225 feet to cover. On these intermediate lines advantage is taken of a new set-up, developed in this district, commonly known as the "Cowboy." Fig. 11. After the muck has been removed by the 15-inch lines, a pillar will be left directly under the line. This pillar is removed by redriving the 10-inch lines on the new grade, and sluicing away the pillars. Another method is to follow a retreating program, pulling back the main line and resetting the giant so that the pillar just ahead of the giant can be worked. This system is probably cheaper than resetting the 10-inch lines, but has the disadvantage of requiring a longer period of time for completion.

Stripping moss when the ground is thoroughly thawed is not a particularly difficult problem; so long as the giants are spaced right, a fairly good pressure is obtainable, and the right size nozzel is used. When the ground is not thoroughly thawed, however, the stripping of the moss is very difficult.

Fig. 11.
A "Cowboy" sep-up illustrating a new method of attaching a 5 inch gate valve to the throat of the giant. This does away with a 10 inch gate valve between the pipe and the base of the giant.

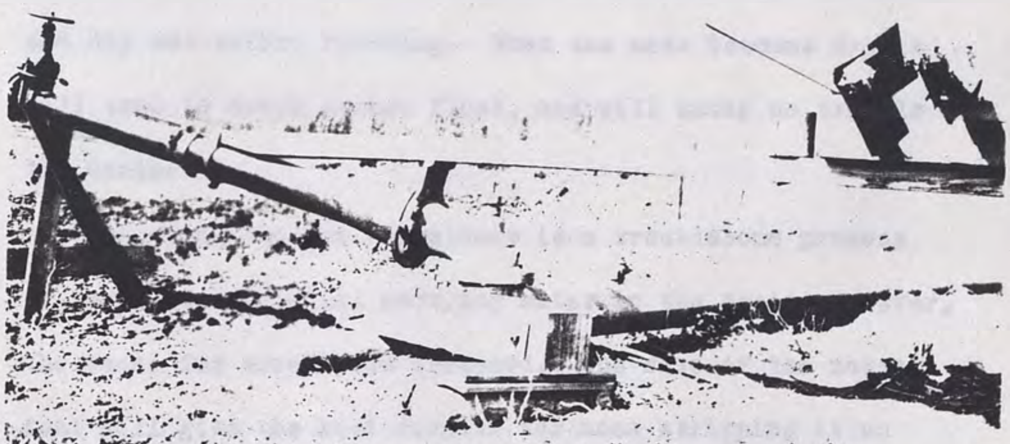


Fig. 12.
This giant installation illustrates one method of tension bracing. See plate 3 for engineering details.

When the moss is only slightly thawed, the face of moss that the water stream has to work against is not very large. When this condition exists, the ability of the "piper" is an important factor. As long as he keeps the stream of water hitting the bottom of the face, the water will cut fairly well. If the stream hits too far back or too far ahead, the face will be tapered and the cutting power of the stream cut down, in some instances as much as 50 percent.

The spacing of giants for moss removal is a more or less open question. The spacing varies according to the pressure and the size of the nozzel used. At 100-pound pressure the radius should not be much over a 100 feet. As the pressure goes up, the radius gets larger. For a pressure of 150 pounds a radius of 200 feet can be used. The spacing for muck and tailings will be discussed later.

After the moss has been stripped, it will be found advisable to let it lie on the ground for a few days to drain and dry out before removing. When the moss becomes dry it will tend to break up and float, and will cause no trouble in the drains.

Removing the moss sometimes is a troublesome process. If there is sufficient carrying water in the drain, however, the cause for trouble is lessened. The size of the nozzel that will give the best results for moss stripping is an open question. A 3-inch nozzel under a given head has greater cutting power owing to the compactness of the stream.

A $3\frac{1}{2}$-inch nozzel under the same head has sufficient cutting power and also provides sufficient water to transport the material away, a factor in which the 3-inch nozzel is deficient. A 4-inch nozzel works well, but requires a large amount of water which sometimes is not possible to secure.

Spacing for Tailing Removal.

In spacing giants for laying out a plant for the removal of tailings advantage must be taken where possible, of all the local conditions. The problems met with in Tailing removal are so varied that one cannot generalize the process.

The effective distance a giant can be worked on tailings is probably in the neighborhood of 175 feet. Beyond this distance in some cases the stream will work efficiently, but for this condition to exist, everything must be in its favor.

The simplest type of tailing removal is where tailings can be "piped" over into an area that has already been stripped, and is within the prescribed radius. The giants are spaced 200 feet apart and the tailings are merely pushed over the edge. Wherever possible, this will be found to be a cheap method of handling the tailings. Another method is to advance through the center of the strip of tailings, blowing them to both sides and working the muck in the area from which the tailings have been removed. The lines are driven on the other sides of the tailings, and they are blown into the area from which the muck has been stripped. In a case where the pressure is not great enough to blow the tailing off the strip from which the muck is to be removed, trenches may be dug with a steam shovel and then the muck worked with giants. When the tailings are blown into the finished area, less pressure will be required, because the grade is favorable and the tailings are easier to move.

The cleaning off the tailings from an area to be worked, 3 giants working in conjunction with one another are sometimes used. One line is driven through tails. The two outside giants are usually kept about 50 feet or so ahead of the center giant. The tailings are handled from the center of the machine to either of the side giants as a continous operation. In this process the tailing face will probably be in the shape of a V. The giants are moved ahead steps determined by local conditions, usually 60 to 80 feet.

When a large area of tailings are to be removed, the fluming system is sometimes used. A ditch is dug down below the contact of the muck and tailings, and a flumes placed in this ditch at a suitable grade. The tailings are then piped into the flume and carried away. Often it is necessary to place a giant at the outlet of the flume to stack the tailings. The use of flumes as a means of tailing removal is an effective method, and has some very good points. The tailings can be handled faster in this manner.

In handling tailings it must be kept in mind that when a load of tailings is started in motion by a stream it is much cheaper and easier to keep them in motion by having another giant placed in the proper position, then to push them as far as possible, move up and start them in motion again. Handling tailings requires more skill than handling muck on the part of the piper, and the man operating the giants on tailings should be thoroughly instructed as to the correct method. This is not an easy task as there is a tendency for pipers who have piped gravel in some other district to follow the same practices used in the particular locality in which they have worked and many times their methods are not suitable for the particular job.

The size of the nozzel, and pressure, for tailing removal are subjects of more or less divergent views. Obviously until the cost of bracing becomes excessive, a high pressure is favorable for tailing removal. The size of nozzel, in turn, depends upon the amount of water available and the pressure. For most tailing work a $3\frac{1}{2}$-inch nozzel seems to work the best. In some cases the 4-inch nozzel has been worked effectively but water duty is generally higher when the $3\frac{1}{2}$-inch nozzel is used. In all cases of tailing removal, the area should be mapped, showing the definite outline of the tailings and the plant laid out to fit local conditions.

Spacing For Muck Stripping.

As has already been discussed under the nature of frozen muck there are many different kinds of muck, and the ideal spacing of giants depends to a large extent upon the nature of the muck. It is practically impossible, however, to take advantage of all these conditions so a radius of about 225 feet can be assumed as the correct radius.

The following table shows the radii for different pressures.

BEST SPACING FOR GIANTS.

Pressure	Material	Working Radius
100 lbs.	Muck	175 feet
120	"	200 "
130	"	225 "
140	"	250 "
100	Moss	100 "
130	"	150 "
140	"	175 "
100	Tailings	100 "
120	"	150 "
140	"	175 "

In working an area of muck, a definite plan must be kept in mind, and the plant laid out accordingly. One important fact to consider is allowing each giant to have a working radius of 225 feet, or whatever radius is assumed throughout an area of 360 degrees. If this is carried out the full value will be obtained from the equipment and every time a giant is operated it will do a full quota of work.

In laying out a plan for muck-stripping, advantage is taken of lines already laid for moss-stripping, as has previously been discussed. A definite plan must be kept in mind for the removal of muck pillars. This can be accomplished either by laying 10-inch lines or using the retreating system as already discussed. The factors which determine the method to be used are available time and the cost of laying new lines.

If high pressure water is used the best plan is to use permanent set-ups as much as possible, because for this type of set-up the bracing cost is high. For low pressures it is advisable to advance and retreat over the area.

Bracing of Giants.

Bracing of giants is one of the most important problems that confronts the operator in laying out his stripping plant.

For low pressures, for example, under 70 lbs. per square inch, the bracing is fairly simple. Holes are bored through the head-block, permitting the entrance of a steel shaft or pin. The pins are driven through the headblock and down into the frozen muck. This type of bracing serves to hold the giant in position. Where the muck is thawed, compression braces are placed in front of the machine as an additional brace.

In high pressure bracing it is necessary to have a much stronger system. Usually, a tension deadman is placed about 10 feet behind the machine, and rods are bolted to the head-block. A turnbuckle is usually placed on each rod so that all slack can quickly be taken up. This type of bracing is sometimes supplimented with compression braces and end braces to take care of side thrust.

Whenever the machine is set near the pipe line, rods are used to tie the machine to the valve. This is a very satisfactory method. See prints at end of paper for correct methods.

Size of Nozzel.

The size of nozzel best adapted for different types of work is an open question. For the number 2 giants used in this district the only size nozzels that are practical are from 3 to 4 inches. The 3-inch nozzel has the greatest cutting power, but does not have a large enough amount of water to carry off the material cut. The range of the nozzel is greater than the range of either the $3\frac{1}{2}$ or the 4-inch nozzel. Where the transporting power of the water is not especially needed, a 3-inch nozzel can be used successfully. It takes approximately the same amount of water to operate three $3\frac{1}{2}$-inch nozzels as four 3-inch nozzels. For the removal of muck the 4 3-inch nozzels might prove the most effective while for moss and tailings the $3\frac{1}{2}$-inch will prove the best.

Often when an area is being worked, part of the muck will thaw and be carried away before the remainder. This often causes small humps of muck to be left, which are slow to be removed and cause delay. A small fire hose taped into the main line with small sprays connected at the other end will thaw these ice and muck humps very quickly with a much smaller amount of water.

Drains.

The subject of drains is a very important one for muck removal. The whole program really depends upon the drains, and the proper place for the drain should be carefully chosen.

Drains can usually be made with water, but in some places mechanical equipment may prove to be more effective. The purpose of the drain is, of course, to provide a channel through which water can transport the muck to the river or creek which carries it away. The grade of the drain governs to a large extent the carrying power of the water. The carrying power of the water varies with the power of the velocity. While muck has been carried away with as low a grade as .225 percent, a .5 percent proves much more effective and should be used if possible. The solid content of the water varies in the drains at different places, according to changes in grade, and relative positions of the giants. For muck, however, the solid content will run about 1¼ pounds per gallon.

Rate of Thaw.

The average rate of thaw is difficult to determine. The average seasonal thaw through moss and muck will be in the neighborhood of 3 feet. After August there is very little thawing progress. It would seem that this would be the best time to start moss stripping.

The average thaw in areas free from moss is about as follows: 1 hour, 1 inch; 4 hours, 2 inches; 12 hours, 3 inches; and about 4 inches for 24 hours. In piping muck the rate of thaw is important. The plant should be laid out so that every machine will be worked every 12 hours. This will take advantage of the thaw, and will keep a fresh face exposed to thawing action at all times. It is of vital importance to have a definite procedure of working giants so that, as far as possible, thawed material will be piped at all times.

Water Duty.

The water duty is really the result of all other factors. Everything done on the hydraulic plant should tend to increase this figure. While a duty of 30 cubic yards per M.I.D. has been obtained, an average figure is somewhat closer to 20 cubic yards for the same amount of water. In order to keep a record of the water duty, the piper should be furnished with report blanks, showing water pressure at the nozzel at the start and end of each run on that giant, size of nozzel used, and length of time. From this data the season's average may be computed.

AREAS OF NATURAL THAW

Classification of Thawed Areas.

The bodies of gravel that are naturally thawed should be well outlined before any attempt is made to thaw the ground. These areas should cover a considerable area of ground on most of the creeks, and represent cheap yardage for the mining company.

These areas may be divided into three classes. (1) The type of thaw which is found where water has seeped through old drift workings. (2) Channels of permeable ground or gravel through which the underground waters flow. (3) Thaw formed by spring water which has good drainage conditions through gravel.

Prospecting for Thaw.

Before the prospecting for natural thaw is started, some information is available and should be tabulated. The drill logs should be examined for indication of thaw. The character of the ground will indicate, to one who is familiar with the creek, where the thaw might be expected. Much valuable information can also be secured from the prospectors and miners who have previously mined or prospected in that particular creek.

After all this information is secured and the blocks of thawed ground are to be determined, either one of the following procedures can be adopted.

The areas to be prospected is laid out in blocks 50 or

100 feet square, and a steel bar driven into the ground at each of the block corners. The method of telling thaw from frozen ground by means of the bar will be described later. After each corner has been probed, holes are put down in between each of the corner holes and so forth until the thaw is determined within 25 feet. This has been found to be close enough for most work. If an area of frozen ground is to be outlined, another method is to drive bar holes 50 feet apart across the valley at intervals of 300 feet, and then go back and locate the boundaries by driving one or two holes every 100 feet.

Both of these systems are given in a general form and their success depends upon the knowledge and capability of the man in charge of the prospecting. He must be able to summarize all the different features that are known, and from them work out a suitable system for prospecting.

Probing.

The method of probing or driving bar holes is very simple. In the first place the necessary equipment are: steel bars, a ladder, a sledge hammer, and a pair of twisters. The operation requires two men. The size of the steel bars used depends upon the depth of ground. In much the same manner as with drilling rock with a drifting machine, different sized bars are used. The hole is started with a fairly short bar that is comparatively thick; when this bar has been driven to its full length it is pulled out and a longer, thinner bar is driven into the hole, and so on, until bedrock is reached.

A ladder must be used for the man driving the bar to stand on. The ladders used are regular stepladders and range up to 20 feet in height. When starting, one man holds the bar and the other man climbs the ladder and then drives the bar into the ground with the sledge hammer.

The size of the bars used range from 3/4 inch to 1¼ inches and the holes are usually started with a 12 to 16-foot bar. The hammer used is usually a 10 or 12-pound sledge. For deep ground a 20-foot ladder is used and for shallow ground an 8-foot ladder is used.

The method of telling whether or not the ground is thawed is fairly easy. In frozen ground it is almost impossible to drive the bar down, and when it is hit it will ring and tend to bounce. In the frozen ground the bar cannot be twisted without much effort because it will tend to stick. In the thawed ground the bar can be driven much easier and when twisted it does not have as much tendency to stick.

Rate of Probing.

The rate of probing of course depends upon many variable factors. Usually, however, two men should probe from 75 to 100 feet per 10-hour shift. In thawed ground the bar will be driven a minimum of 1 inch to 8 or 10 blows with the sledge hammer. In frozen ground the rate is almost nil.

The maximum depth of economical probing has been set at 42 feet. When the ground reaches this depth, probing will be found to be uneconomical.

Several things must be kept in mind when probing, and experience only can be relied upon. For instance, when the bar sticks it might not be on account of the frozen ground but because a boulder has been encountered. Again there might be a thin streak of frozen sand that is hard to drive through. Two men of average intelligence, however, will soon learn to be on guard for these things and the work can easily be carried on successfully.

THAWING

The frozen gravels encountered in the north presented a new problem to miners. The ordinary method of placer mining suitable to thawed or cemented gravels cannot be used. The frozen gravels are as a general rule too tough and resiliant to be blasted and mined like solid rock. An exception to the above will be taken up later in this paper.

Wood Fires.

The first and crudest method of attacking the problem is by building wood fires. While this method was first used in all of Alaska's early mining camps, it is only used at the present by prospectors far from a source of supplies. Only a small portion of the ground is thawed at a time, but the method is fast enough for the hand operator and suits his needs admirably when he lacks machinery and often has to be content with the barest necessities, particularly when prospecting new country.

Improperly used, a wood fire is not only a complete failure as a means of thawing, but it is also a source of real danger. Properly used, it enables the miner to thaw his ground and extract gold when other methods are impossible due to a lack of equipment. Care has to be exercised in order to confine the thawing within bounds so that caving does not result and precautions have to be taken to prevent the operator from being smothered in the fumes before he can escape after lighting the fire.

Shaft Sinking.

The first use to which wood fires are put as a thawing agent are for sinking shafts on a new location. The surface covering of muck and moss are extremely resistant to thawing by any means so it is generally picked loose. Below the muck lies the gravel which is readily amendable to thawing by fire. In sinking the problem that confronts the miner is that of controlling his heat action so that the shaft maintains a constant size. Unless much care is taken and some degree of skill shown, the hole may start as a conservative, five by three-foot shaft and be enlarged downward in pyramidal shape resulting in a veritable room by the time bedrock is reached. This, of course, causes increased labor since all the thawed dirt must be taken out of the shaft or the walls will not stand. A hole of this kind is also dangerous since caving is bound to result because of the excessive undermining.

The problems in shaft sinking with wood fires are: first, to burn the wood completely; second, to utilize the utmost heat value obtainable from the wood in order to get as big a "thaw" as possible; third, to force the heat downward and not out into the walls.

The first problem, that of effecting a complete combustion of the fuel is met by building up the wood so that it and the shaft combine to form a sort of fire-box and stack. Any natural draft may be tested for by means of a lighted candle held at the bottom of the hole. One end of the shaft serves as a downcast and the other end serves as an upcast or stack. The bottom layers of the pile of wood in the hole are composed of fine, dry, highly inflammable material piled so that air will be readily drawn through the burning material and up the side of the hole which serves as a stack. The fire is lighted at the downcast end. Usually it is not necessary to have a partition in the shaft, but in deep shafts a canvas should be hung between the two ends in order to keep the air moving. This method of piling results in as nearly a complete combustion of wood as can be obtained. In order to confine and direct the heat, green wood is placed on the top and sides of the pile to reflect the heat downward and keep it away from the sides of the shaft. This green wood also causes the fire to be slower burning and hence more effective as a thawing agent. Lastly, dirt may be thrown over the top of the wood, or if shoveling plates or corrugated iron roofing is available, these may be placed on top. This is effective in confining and deflecting the heat downward.

A properly laid wood fire for shaft sinking contains about one-twentieth of a cord of wood and thaws the shaft bottom from 12 to 20 inches in depth depending upon the character of the gravel.

Drifting.

Wood fires are also employed in thawing the ground for drifting and the process is even more difficult to apply than in thawing for sinking. The roof of the drift must be protected from the heat as a thawed roof in a drift is very dangerous. Drifts in pay gravel are usually about six feet high.

By building a wood fire low, from 18 to 24 inches high, the heat naturally tends to raise to the roof along the face and is dissipated before it can thaw the roof to any extent. A skillfully laid fire will thaw the gravel from 15 to 21 inches in advance.

On the floor of the drift close to the face shavings, paper and fine kindling are placed. On top of this dry wood is placed. When this method was first used, the dry wood was put on end against the face of the drift and green wood placed on top of this but the sticks placed on end did not burn completely and the fire did not give its full heating value to the gravels. The practice now when wood fires are used is to lay the wood on its side parallel to the face of the drift with the ends interlaced. The top of the pile is sloped away from the drift. Green wood is used for the topmost layers and these are covered with dirt and rocks.

As in shaft thawing iron shoveling sheets or pieces of scrap sheet iron may be used as covers. When possible the warm gravel is left at the face until its heat is given up in the thawing or sweating of the ground.

Hot Rocks.

Thawing by hot rocks is not applicable to gravels containing a great amount of ice. In this type of ground rocks are heated in a fire at the surface and then dropped to the bottom of the shaft or carried underground and piled against the face of the drift. Inasmuch as the rocks used in this manner have to be hoisted from the shaft to the surface for reheating, the method is not satisfactory and is never used if wood fires can be used.

Steam.

Thawing by steam was first used in the Dawson camp in 1898 on a commercial scale. Mr. Fred Lewis of the Lewis Machine Shop, Fairbanks, (my next door neighbor) claims the distinction of being the first man to use a steam point. His account is as follows: Hicks of Tacoma devised a method by which he believed frozen gravels could be thawed. This method employed a rock-drill with which the frozen gravel was drilled. In this hole a piece of pipe attached by a hose to a boiler was inserted and the steam from the boiler was to be forced into the ground under high pressure.

An outfit was made up consisting of a small upright boiler, rock-drill, pipe, hose, etc. This outfit was sent to the north in the fall 1897 and fell into the hands of Lewis and his partner, Dalquist.

During the winter of 1897 Lewis and Dalquist tried the new outfit out at Gold Hill. The method was a failure due chiefly to the fact that muck and gravel proved to be exceedingly difficult to drill. They finally succeeded in drilling a shallow hole, but the drilling was so slow that the partners decided to insert the pipe in the drill hole and turn steam through it in order to ascertain the thawing power of steam.

A point consisting of a piece of pipe with a hose coupled to it was propped up in the hole, the steam turned on and the partners turned their attention to other matters. Returning some time later Lewis noticed that the point was leaning and might fall. He straightened it. As he did so the point penetrated the muck it had thawed and he found that the point had made more progress in a short time than the rock-drill had made in several hours.

Lewis then devised a "tee-Head" point. This consisted of a tee with a piece of pipe, a plug and a nipple inserted. By means of this contrivance they could sink the point by driving lightly on the plug. They continued to thaw in this manner during the winter.

EQUIPMENT OF PLANT FOR STEAM THAWING

A plant suitable for steam thawing consists of a boiler located on the surface, pipe lines for conducting the steam from the boiler to the working places, underground or surface, hose to provide a flexible couplings from the pipe line to the nozzel or point and lastly, the point or thawing end of the apparatus. The story of the development of this equipment is interesting. It is a phase of placer mining operations unique to the north. While accurate data are lacking, it is probably that fully 60% of the gold produced in this region has come from gravels thawed by this type of point. The details of its development will be described as fully as possible.

Boilers Coil Type.

It is said that the first boiler was used in the early Alaskan mining camps when an ingenious "old timer" coiled a pipe and placed it in a wood fire thus making a crude boiler. What ever the truth of this statement it served its purpose and was very easy to construct.

Porcupine Type.

The type of boiler which was universally used by the early miners and prospectors, and for that matter is still used for prospecting due to its light weight, was the porcupine or "Porky" type. Briefly this consists of a core into which is fitted short pieces of pipe or quills. This core or water box rests on a support which serves as the fire box. The whole is surrounded by a sheet iron jacket. A shallow hole is usually dug beneath the boiler and pipes laid across this depression form a crude grate. The quills are usually of $1\frac{1}{4}$ inch pipe, but occasionally are of one inch diameter screwed into an eight-inch pipe. They are put in as close together as possible, angled in all directions and are of varying lengths to fit the jacket. In one satisfactory type of "Porky" an arrangment is made whereby the quill is prevented from going dead. Circulation is induced by means of a strip of sheet iron inserted in the quill and not quite reaching the end. The stack of the boiler surrounds the top of the central core which at this point makes a steam chamber. The heat of the escaping gases drys the steam. The water level is kept above the quills and the water glass is placed outside the jacket. Water is fed to the top of the eight-inch pipe by means of an injector line, but may be attached directly to the top of the steam chamber.

Doghouse Type.

A later adaption of the pipe boiler is the Doghouse boiler so named because of the resemblance to the shape of a dog house. This boiler consists essentially of a large fire box lined with coiled pipes. It is much heavier than the Porcupine boiler and was used for more elaborate installations.

Later the ordinary types of fire box boilers were widely used, but it is to be noticed that the types of boilers used by prospectors and described above were made of short pieces of pipe coupled by various fittings, the whole simply and easily made from the stocks available.

Steam-Lines & Hoses.

The development of this part of the equipment is in no way unique. Under pioneer conditions the arrangment naturally was crude. Insulation for exposed pipe piping was not available and undoubtedly the losses of heat due to condensation were very large. Later this condition was somewhat remedied, but in any case the installations are deficient in the matter of heat conservation.

One piece of equipment worthy of mention is the leader or arrangment whereby a number of hoses were attached to one pipe, or a number of points attached to one hose. Mechanically it is simple, consisting of the combination of pipe fittings necessary to split the steam supply into several jets. The device is mentioned, however, to draw attention to the fact that not only one, but numerous points are operated from one boiler.

Points.

The steam point was the part of the equipment which gave the most trouble. It had to be sturdy and strong in order to stand up under the repeated hammerings necessary to drive it into the frozen gravel. It was essential that it be inexpensive for large numbers had to be used in any mine. This

This latter requirement was later fulfilled by the use of a few heavy points which were used to thaw the hole into the face. Once the hole was in the heavy point was withdrawn and a light point, or sweater, made of common pipe was inserted in its place.

Pipe or Sweater Point.

The first steam point used was what is known as the sweater and was practically the same point that Lewis had devised. It consisted of a tee-head 3/4 x 3/4 x 3/8 inch, plugged at one end, a common $\frac{1}{4}$-inch pipe four or five feet long screwed into the other end and a 3/8-inch nipple screwed into the take-off. The hose was attached to the nipple.

The point was too light to stand up under the hammering required to drive it into the ground; the pipe would fail and the head be bruised until it was ruined. The expense of replacing the pipe would have meant little to the early miners had there been any pipe available. Heavy pipe was not among the early stampeder's list of supplies, however, he had to find a substitute. Rifles were common, and the rifle barrel was used as a substitute for pipe.

Gun Barrel Point.

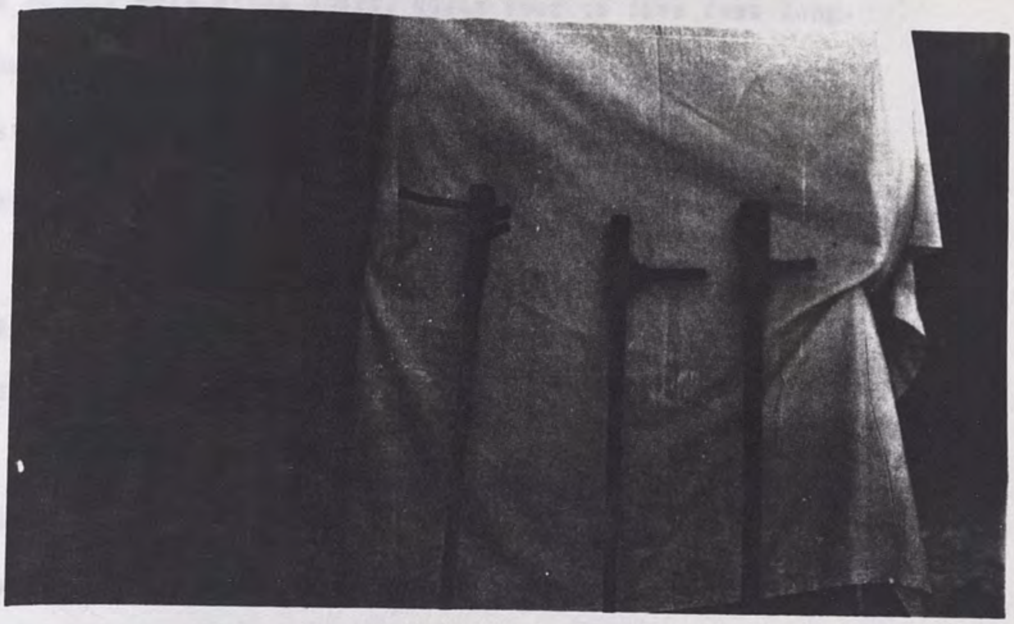
This point was not essentially different from the pipe point except for the fact that an old rifle barrel was used as the point and stem. This gave the point its name. This was a distinct advance over the sweater type because the barrel was heavy enough to stand hammering without bending. Breakage was reduced, but gun barrels costing around twenty-five dollars each were expensive, and hard to secure in large numbers. Then to, they were short, and it was often necessary to weld two barrels together in order to get a point of sufficient length. Later hydraulic pipe was imported and used as stems. a and b in Fig. 13 illustrate gun barrel points, while c is the nipple point.

Nipple Point.

The successor of the gun barrel point was the nipple point. This type of point was introduced by R. K. Jones of the Klondike Thawing Machine Company. He had them manufactured in Seattle and they were shipped to Alaska in great quantities.

This point had a cast head which was shrunk onto the end of the stem pipe. A nipple was screwed into the head at right angles to the stem, hence the name "nipple point." In this point,as in all succeeding points, a hole was drilled through the solid head above the pipe attachment. Through this opening a rod is inserted to serve as a handle and the point is given an occasional turn while being driven. This prevents clogging and sticking.

As in the two preceding types, breakage proved to be a source of trouble. In the earlier models the cast head came down square with the pipe, and pipe and head were joined with



a. b. c.

Fig. 13.

Fig. 14.

a shrink fit. The pipe was not strong enough to stand the heavy strain on it at the junction. Breakage was frequent. The points were still short, about four to five feet long. Later the bottle neck was developed. This type of neck distributed the strain on the junction between pipe and head. The nipple point is illustrated in Fig. 14, a.

The next advance came when the wrought iron head with the welded nipple was introduced. The heads of these points mushroomed quickly from the pounding necessary to drive them so they were reinforced by the insertion of a wedge of a octagon tool steel. This provided a resistant head. The head was welded on the pipe instead of being shrunk on and this junction was often reinforced by the welding of another piece of pipe over it.

At first 3/4-inch common pipe (with the exception of the gunbarrel point) had been used for the stems of the points. Breakage of this stem was frequent and, about 1904, points were being made using single X hydraulic pipe. Later double X and in some cases triple X was used.

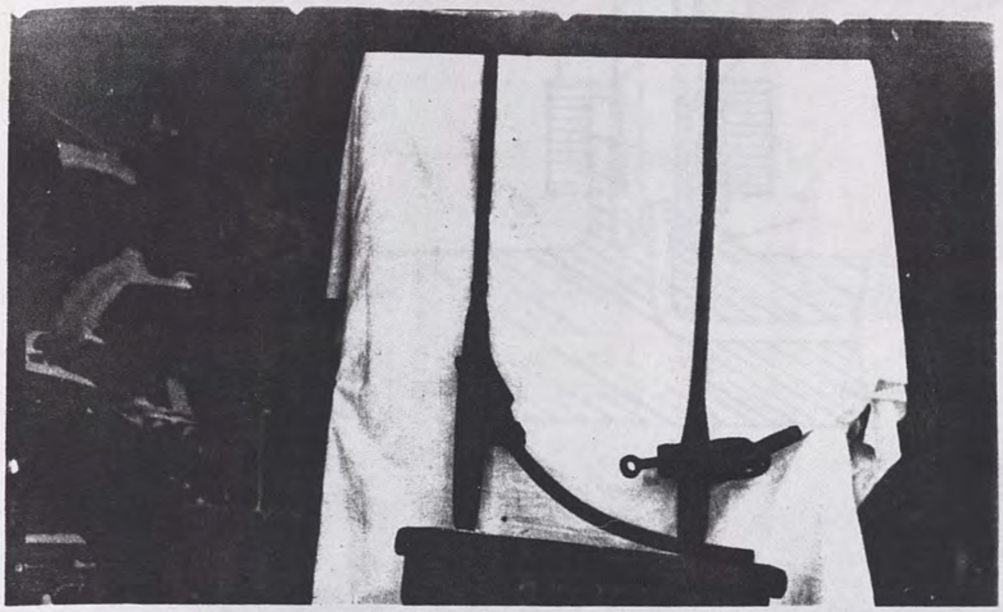
The nipple and its method of attachment gave the greatest trouble in this type of point. It stood out from the stem at right angles where it was usually struck by the driver whenever the head of the point was missed. This was quite frequently done in poorly lighted drifts. This breakage was costly since the absence of a blacksmith shop at the mine made it necessary to take the point to the nearest shop for repairs. The charge for welding a nipple was $2.50. With a battery of 50 to 100 points, as was often the case, this breakage accounted for a large part of the repair cost as well as the cost incidental to lost time and labor.

In order to overcome this excessive breakage of the nipple, the socket point was finally developed. The first one to come on the market was patented by a Fairbanks shop in 1907. This point and the clamp were known as the Samson Patent Nipples Steam Point and Steam Point Clamp.

Samson Patent Nipples Steam Point Head.

In this point as illustrated in Fig. 16, a and b, and Print No. 1, the hose is held to the head by means of two barrel-shaped lugs (E) placed around the end of the hose (in which a nipple (D) is inserted to prevent the crushing of the hose) and then clamped into the socket (B) by means of yoke (A) and the collar (C). The yoke is tightened by means of nuts as shown in the sketch.

This type of clamp possessed many distinct advantages over previous devices. It provided a steam-tight joint, was sturdy and so constructed that glancing blows falling on the clamp did not break off a vital part as was the case with the nipple point. It has two disadvantages; one was the number of parts, as can be seen in the sketch, there are seven pieces: one nipple, one yoke, one collar, two lugs, two nuts. These parts are small and easily lost in the dark, wet, cramped working places underground. Another

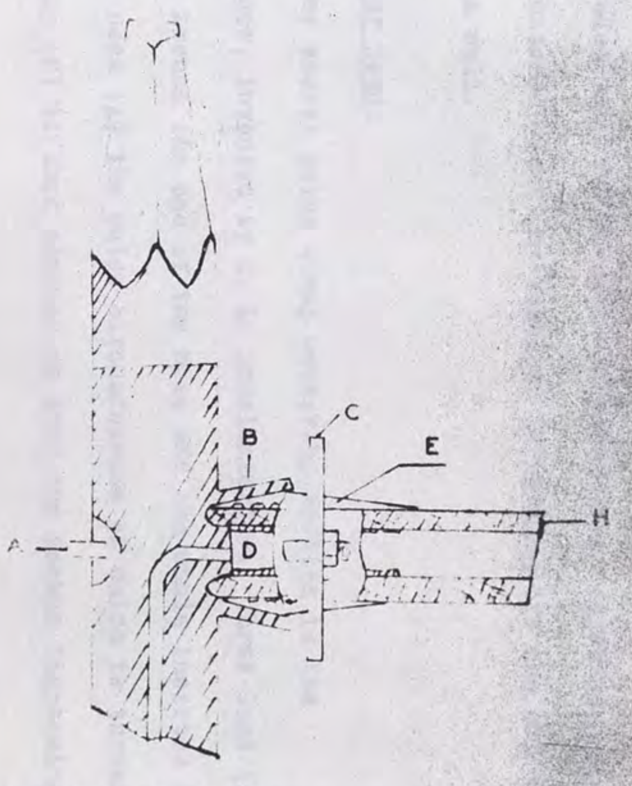


a. b.

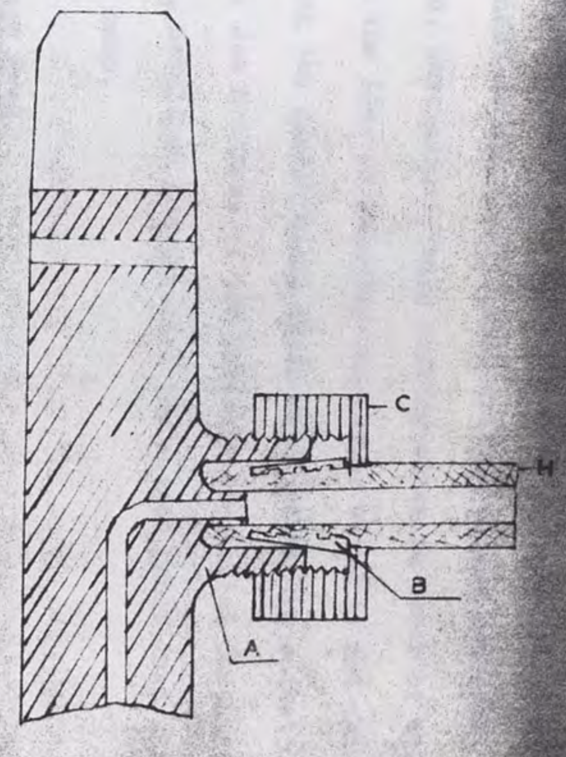
Fig. 15.

a. b.

Fig. 16.



SAMSON HEAD



SCHELENBERGER HEAD

disadvantage was that the clamp did not fit snugly to the head, but protruded so far that it made driving clumsy and sometimes impossible, particularly when driving close to floor or walls.

With the idea of reducing the number of parts and thus simplifying the Samson Clamp while still using the socket principle, Joe Matthews of the Northern Commercial Company, Fairbanks, developed and patented the socket point head which bears his name.

The Matthews Head.

This clamp illustrated in Fig. 15, b, consists of five parts. These are a hose clamp, securely bolted on the end of the hose and holder. The hose was tightened against the socket by tightening the long bolt shown in the illustration.

While this clamp was compact and easily handled underground it protruded so far from the point head that it proved cumbersome and in this respect was worse than the Samson Patent Head. It also required constant tightening and adjustment which not only consumed time, but resulted in wearing off the end of the hose as well.

Shelenberger Head.

Another socket point clamp deserving mention is the Schelenberger, invented by C. L. Schelenberger. Three lugs (B) are placed around the end of the hose and the whole inserted in the socket head (A) the outer circumference of which is threaded. A Clamp (C) is then screwed on over the socket tightening the end of the hose against the head. Fig. 17, a and b, and Print No. 1.

The principle of this point clamp is excellent, the clamp is small, it is close to the point so that it permits easy driving and it provides a steam-tight joint. The head was never very widely used, probably due to the fact that it, like the Samson Head, had several small parts which were difficult to adjust. The threaded parts were also rather fragile for the severe duty required.

Other socket heads were developed but did not meet with any great success, Fig. 15, a, illustrates one of these known as the Finnigan Head.

Barrack Patent Head.

Probably the most successful head and clamp was the one perfected and patented by the Barrack interests. This device did not come onto the market until drift mining was well under way, but in the late years of the drift mining period of the Fairbanks area the Barrack All-Steel Patent Thawing Point was used for the greater portion of the thawing.

The clamp itself as illustrated in Fig. 18 and Print No.2 consists of a holder (A) with a projecting arm which fits into a recession in the solid head of the point and is secured by a bolt (B) which is fastened through to the other side of the solid point head and forms a fulcrum for any strain on the clamp. At the upper portion of the clamp is an angular opening, the inside of which is fitted with corrugations for the purpose of holding the hose securely. This opening may be

a. b.

Fig. 17.

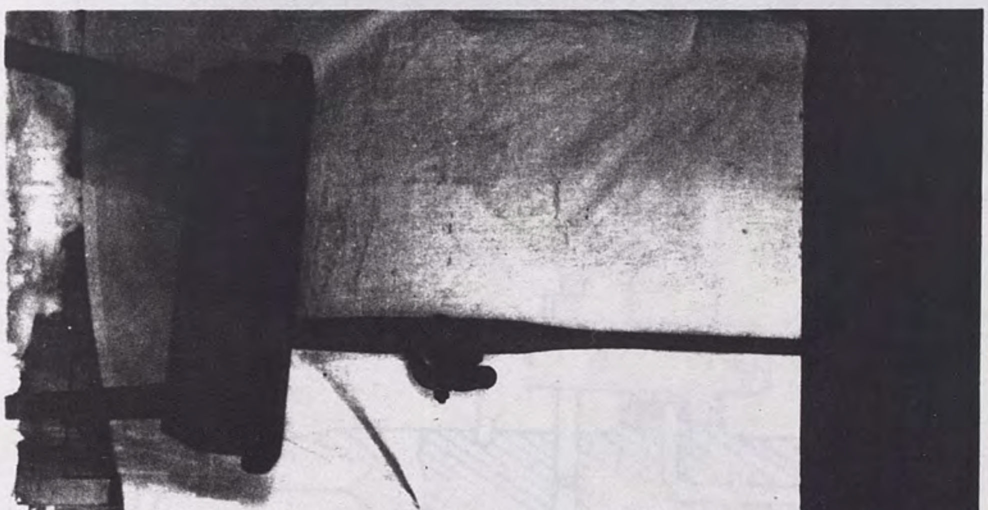
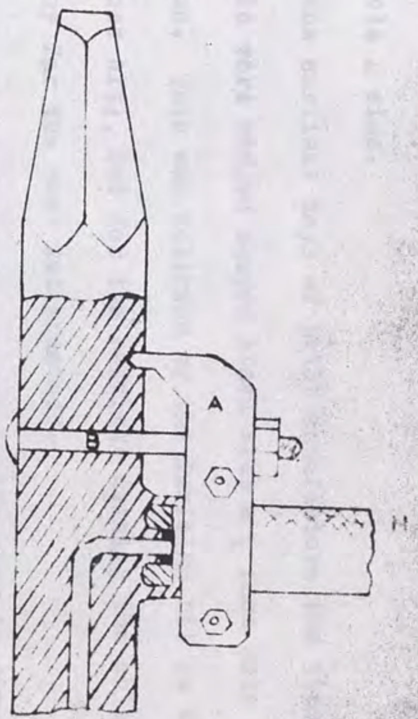
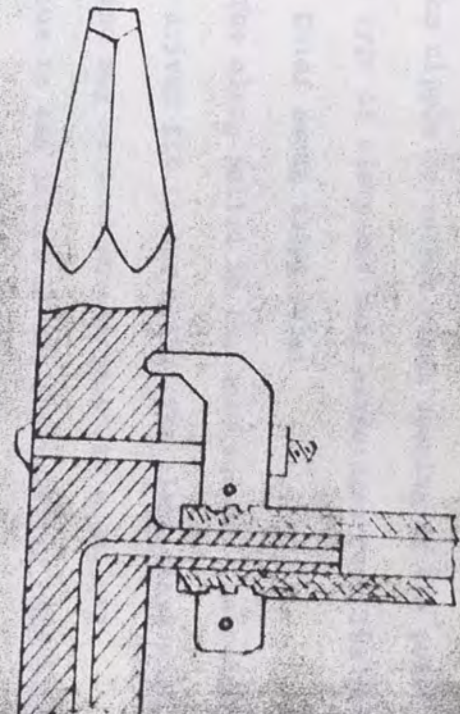


Fig.18.



BARRACK HEAD
SOCKET POINT



BARRACK HEAD
NIPPLE POINT

tightened or loosened by means of two small bolts passing through the clamp. This clamp holds the hose end tightly against the nipple or socket steam opening of the point.

This type of clamp had many advantages over its predecessors. Chief among these were:

1. The clamp bolted to the hose end and the holding bolt is a driven fit in the head. The clamp stays with the hose and may be used on any point in a battery.

2. Due to the nature of its construction, the clamp acts as a brace to the hose and there is no play to wear the end of the hose during driving.

3. There is no projection and the head can be driven directly on the floor of a drift.

4. The head is less expensive than either the Samson Patent or the Matthews Patent.

The Barrack Interests also inaugurated the use of the round, hollow, tool steel stem which took the place of the double X pipe. The 7/8 inch size was substituted for $1\frac{1}{2}$ inch double X size.

In the earliest days of point manufacture the tips of the points were wedged shaped steel with a $\frac{1}{4}$ inch hole drilled in the end. This was followed by the Burleigh bit (a four point cross bit), but for the heaviest driving the chisel bit was by far the most satisfactory.

The length of the stem was originally four to five feet. Later this length was increased to eight and ten feet which was about the longest stem possible to use underground. In thawing from the surface it was customary to use extremely long stems, sometimes as much as 20 feet long. These were driven by men working on ladders or staging. Eventually an anvial attachment was designed to clamp on the stem at any point so that driving could be done while working on the ground.

Cold Water Thawing.

When the rich high grade placer deposits were worked out it became necessary to find a cheaper method of thawing. Around 1915 many different men started experiments on a new plan of using cold water or water at natural temperatures. They all reported satisfactory results, but John H. Miles patented his process in 1920.

The Miles Method.

The method patented by Miles involves the use of water delivered to the ground through thaw points, under low pressure and natural temperatures. As the water leaves the points, which are driven into bed-rock or close to the bottom of the frozen stratum, it thaws and loosens the ground around the point. As thawing proceeds, the cylinder grows larger and instead of the water returning to the surface next to the pipe it works its way to the outer rim of the cylinder and from there follows the frozen rim of the cylinder to the surface. This is quite easy to understand as the material is the least dense where the subsidence is just starting next to the frozen material. Experiments have shown that the cylinder thawed by the water in the gravel has its greatest diameter at the bottom so thawing is most thorough at bedrock.

W A T E R

Temperature.

The temperature of the water used for thawing varies throughout the summer and also for different summers. Water at a temperature less than 35°F. cannot be used with any success in practice. The water temperatures for a system where a dam is placed below the thawing area and the same water is being used over and over again vary from 35 to 50°F. The temperature of the water that is being taken from a ditch and not being in closed circuit will vary from 35 to 60°F. The lower range of water used in closed circuit of course is, on account of the same particles of water, being in contact with the frozen gravel. The average water temperature, however, will range between 41 and 48°F. Over the life of the point, efficiency will average approximately 25% of the available heat.

Source of Water Supply.

Wherever possible, ditch water should be used if the required pressure may be obtained. With the new direct-connected diesel centrifugal pump units water may be pumped very cheaply. Thaw pumps usually pump against a head of about 40 pounds.

<u>Time Required for Thawing.</u>

The most dependable standard upon which to rate the time required to thaw the ground is the amount of water entering the ground, that is, disregarding heat units. The water duty varies over a wide range, being as low as 3 and as high as 30 with an average of about 12 or 15 cubic yards per Miners Inch Day. The time required to thaw the ground is directly proportional to the number of cubic yards or in other words the depth of the gravel to be thawed.

The water duty is influenced to a large extent by the temperature of the water entering the ground. The reports used are generally based on the MID degree which is a self-explanatory term. Using this as a basis from which to figure, the water duty, however, is not as successful as it might be because it fluctuates much more than the duty based on the MID.

The total amount of heat taken from the water obviously depends upon the surface temperature of the water. When warm water is introduced into the ground the percentage of heat units taken out by the thawing action of the gravel is less than when cold water is introduced. Probably the reason for this is that the water while making the circuit from surface to bedrock and back up to the surface again, moves so fast that the time is not sufficient for the removal of more heat units. Thawing, however, goes on much faster when warm water is used, and it is only the percentage of extraction of available heat units that is lower for warm water than for cold.

Fig. 19.
Point pulling clamp with wrenches used for pulling points when ground is thawed. Note the large base used to keep the clamp from sinking into the soft ground.

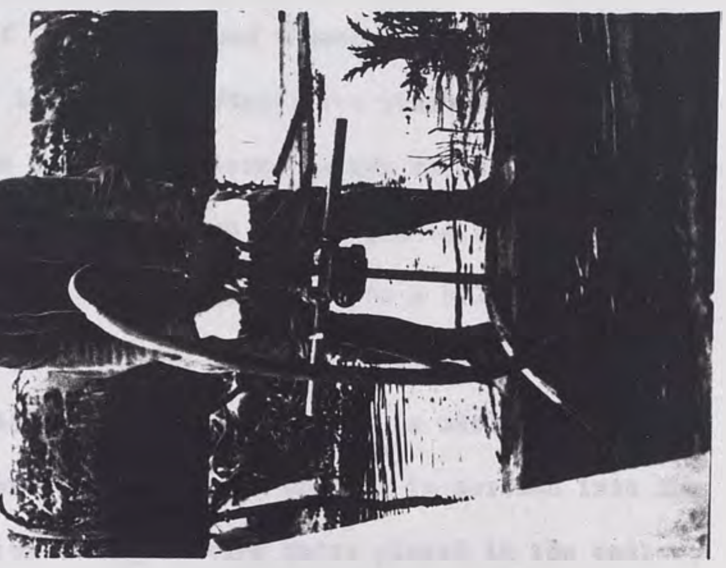
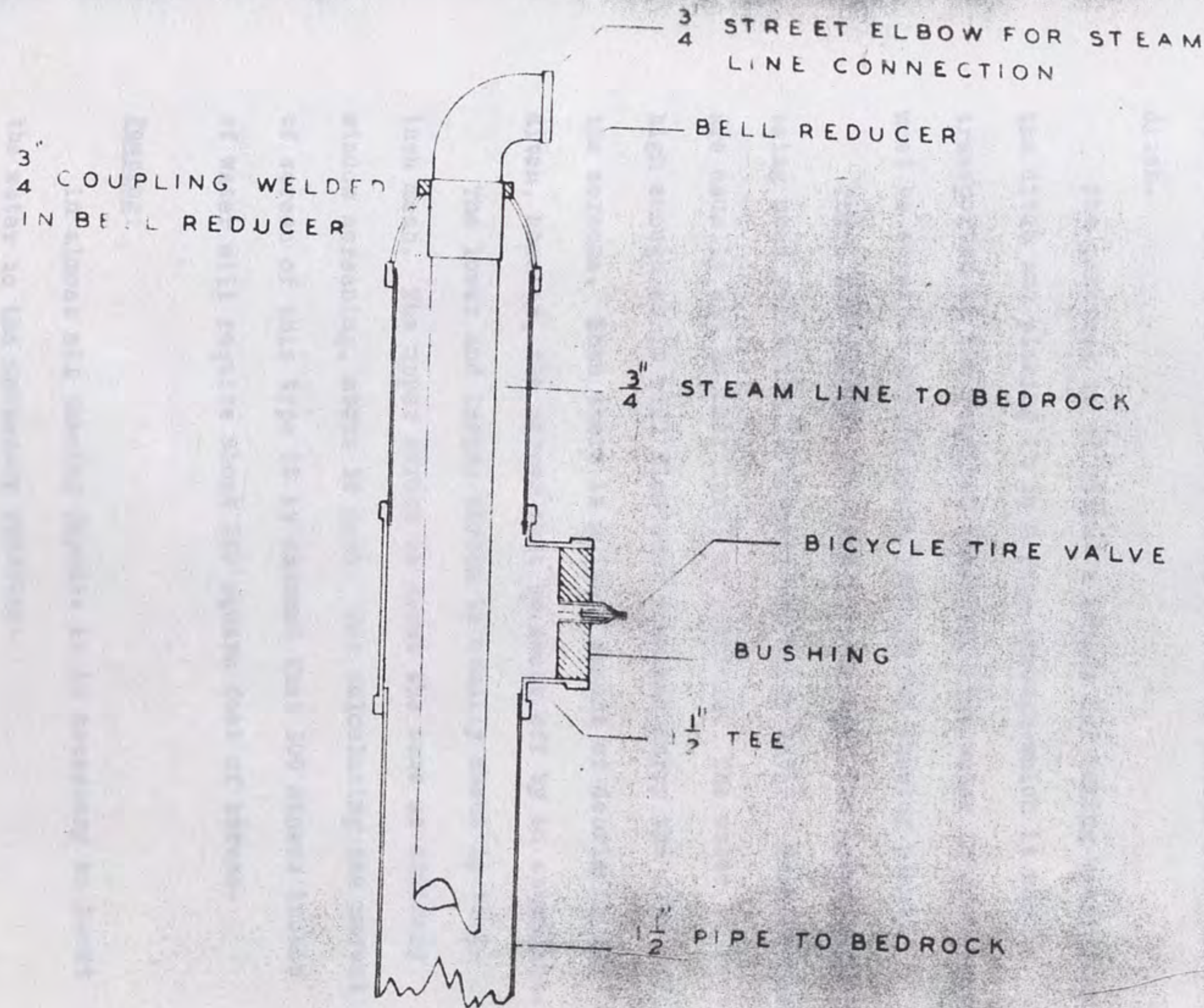


Fig. 20.
Anvil and driving hammer. The hammer weighs 25 lbs. The driving unit may be removed and used on other points.

Another factor to be considered in the time required for thawing is that as the amount of the thawed material grows larger, the water duty grows less. The reason for this is that at all times a certain amount of water, instead of following along the contact of the frozen material and the thawed material, will percolate through the thawed material and as the body of the thawed material grows larger there will be more percolation, consequently, less water is making contact with the frozen material.

For most operations in this district with 3/4-inch points set on 16-foot centers the average thaw time varies from 10 to 90 days, being greatly dependent on the depth and tightness of the gravel. The time required to thaw a block of ground using 1½-inch points set on 32-foot centers is usually two or three years. It must be kept in mind that the thaw season in the Fairbanks season will average somewhere between 3 and 4 months. Some of the deep ground thawed with large thaw points is not completely thawed even after three years and it is necessary to finish the holes with steam. A new method (Print No. 3) has just been devised. A 1½-inch tee is placed on top of the thaw pipe, a short coupling is connected to a bell reducer with a 3/4-inch coupling welded in, a street elbow is screwed in for the steam connection, 3/4-inch common pipe is screwed into the lower end and extends to bedrock, a bushing is screwed into the side of the tee with a bicycle tire valve placed in the center; by pumping air into the 1½-inch pipe once a day the water is kept at the bottom of the pipe and the full value of the steam


3/4" STREET ELBOW FOR STEAM LINE CONNECTION
BELL REDUCER
3/4" COUPLING WELDED IN BELL REDUCER
3/4" STEAM LINE TO BEDROCK
BICYCLE TIRE VALVE
BUSHING
1 1/2" TEE
1 1/2" PIPE TO BEDROCK

is utilized in the bottom of the hole.

Thawing costs about 7¢ per cubic yard on an average in the Fairbanks district.

Penstocks.

The penstocks used in this district are usually of the automatic type, that is, they operate by themselves, the only attention being required is an attendant to keep the screens from clogging with leaves, moss, and other debris from the ditch.

The penstock is of course a device for taking water from the ditch and placing it in a pipe through which it may be transported to the required location. The water in most cases must be screened before going through the thawing plant.

There are usually two layers of screen, the lower layer being used primarily to support the upper layer. These screens are usually set as near level as possible. The water is kept high enough so it will flow over them and carry the dirt off the screens. When there is a large amount of debris in the ditch, however, the screen must be swept off by an attendant.

The lower and larger screen is usually about $1\frac{1}{2}$ to 2-inch mesh. The upper screen is about the same as ordinary window screening, about 16 mesh. For calculating the amount of screen of this type it is assumed that 100 miners inches of water will require about 120 square feet of screen.

Pumping.

In almost all thawing layouts it is necessary to boost the water to the necessary pressure.

Single stage centrifugal pumps directly connected to electric motors or to diesel engines have proved to be the best. A pump that will pump about 6000 gallons per minute with a r0 pound pressure will usually take care of from $2\frac{1}{2}$ to 3 thaw units. Fig. 11 illustrates a 3 unit pumping layout, pumping from a pump at the lower end of a point field. Two traveling screens are in front of the pumping station. All the water, before entering the pump intake, must pass through the moveable screen. These screens are washed with a spray of water to remove any debris that might attach itself to the screen.

Dams Placed to Impound Local Water Supplies.

On some creeks it is necessary to use water from the ditch for thawing purposes because there is not enough creek water to thaw the ground. In this case a dam is built across a low place in the valley below the area to be thawed. The choice of the site depends upon local conditions but it must be placed so as not to interfere with other work on the creek and it must be below the thawing area because all the thawing water or return water from the thawing area must return to the pond created by the dam.

The size of the dam depends upon the amount of water available and the time taken for a complete cycle of circulation. It must be large enough to impound enough water so there will still be water in the dam when the pumps are working at full capacity. A large dam obviously is advantageous. With such

Fig. 21.
3 - 6000 gallon per minute pumps. Note screens for cleaning intake water so the small hole on the bottom of the thaw point will not be plugged. Dam for pond is on the readers left.

Fig. 22.
Thaw field illustrating flange feeder line. Note 6 inch valves connected between flange feeder and header pipe.

a dam there will be no shortage of water for the points, also with a large dam it will not be necessary to sluice out so often. The return water from the points carries a large amount of sediment, muck and mud, into the pond and then the velocity of the water is diminished. This material accumulates in the pond and necessitates the sluicing out of the pond occasionally. The sluicing out of the dam consists of opening a gate built in the lower part of the dam and cleaning out the sediment. With a large dam the interval between the dam cleaning out periods will be longer.

Another point to keep in mind in favor of the large dam is that a larger body of water is impounded, more area is exposed to the sun and, consequently, the water will be warmer.

Transportation of Water to Thawing Area.

The water after leaving the pumps must be transported to the thawing area. As a large amount of water under a comparatively low pressure is used in thawing gravel, a large line must be used. The lines connected directly to the pumps are usually 14-inch pipe. These, however, connect with a larger pipe, the size depending upon the number of pumps used. Often a 36-inch line is used with three pumps, with reductions made on the way to the field. The gauge of this large pipe is quite light due to the low pressure. Slip-joint hydraulic pipe of 12, 14, or 16 gauge is commonly used for this service.

The fittings for this type of service are fairly simple. The most important fitting to be considered is the air valve. Air valves are placed in the high points in the line so that whenever the line is drained by a break or accident of any sort the air valves will permit air to enter the line and prevent the creation of a vacuum which would cause the line to collapse. On a large pipe line it is essential to install air valves and, of course, the more installed, within reason, the safer the line will be.

Another type of fitting is the corporation cock. This fitting is placed in the line similar to air valves. The purpose is to permit the measuring of the flow of water with a Pitot tube. The way in which the corporation cocks are used will be discussed later.

At some point on the line, a pneumatic coupling is screwed onto a nipple welded into the line for the purpose of connecting a pressure gauge. This arrangement is simple and needs no explanation.

The method of assembly is similar to the laying of any slip joint pipe line. An allowance of 3 inches must be made for each length of pipe in the line for the joint. One end of the pipe fits into the other with a driving fit. A large wood block being placed over one end of the pipe (bible) and this is hit with a large wooden ram swung with the aid of ropes. See Fig. 23, where 4 men are swinging the ram against the wooden block. The first time the pipe is used it is good practice to place a band of burlap dipped in kerosene around the end of the larger pipe causing it to expand. After the pipe has been used several times it becomes necessary to wrap the smaller end with burlap to make a tight fit with the female end. In the large pipes

Fig. 23.
"Bull-Gang" laying pipe. Note the 4 men swinging the ram against the "Bible" placed over the head of the pipe.

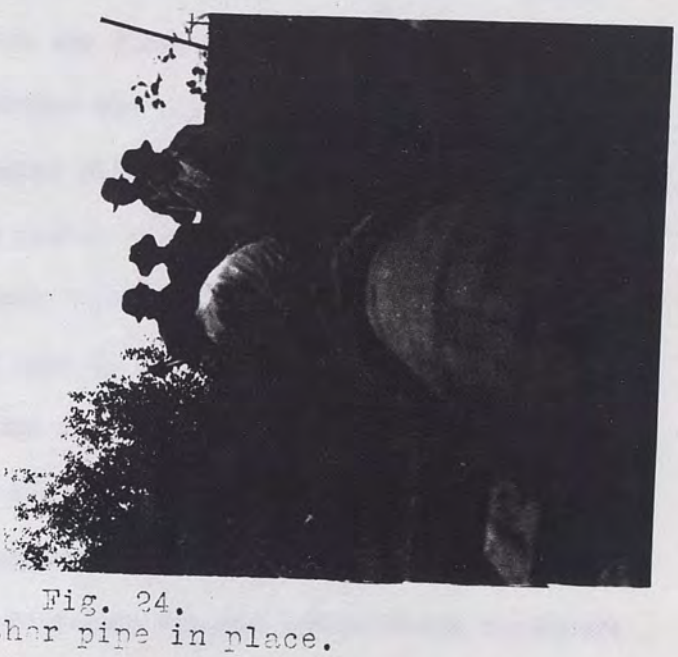


Fig. 24.
Another pipe in place.

there is a large amount of water which necessitates the laying of a fairly good foundation for the line. In a country like the Fairbanks district where the lines must cross swampy ground, the bracing of these lines is sometimes a difficult task. The methods used for bracing are shown in the plates at the back of this paper.

Thawing Units.

The main line that carries the thaw water to the field has 15-inch outlets welded onto it at different places depending upon the size of the unit. This outlet will be either flanged so that a valve may be bolted on direct, or it can be connected to the valve by means of a flanged stub. The valve is bolted to a 11 by 11 by 15-inch tee; the 15-inch end being bolted to the valve. This tee is made of 14 gauge iron and is 4 feet long from end to end on the 11 inch side. Bolted to each end of the tee are flange feeder pipes. These pipes are 11 inches in diameter and are of 14 gauge iron.

These flange feeder pipes are flanged on each end and in the center have a 6-inch outlet. All the lengths of flange feeder pipe are 27 feet 7 inches long except one section which is 4 feet shorter to make up for the 4 feet that is taken up by the tee right at the start. The purpose of the 6-inch outlet is to serve a 6-inch header line. Usually 2- 11-inch flange feeders are connected on each side of the tee, then a reduction is made to an 8-inch flanged feeder which continues for 3 lengths, then a reduction is made to six inches and a six-inch flange feeder pipe is connected for the last header pipe. With this arrangement there will be an opening along the flange feeder pipe every 27 feet 7 inches, and a total of 12 openings. A 6-inch valve is bolted to the flange feeder and to the valve a flange stub is connected. Header pipes are 6 and 4 inches in diameter and are 16 feet long. In the center of each pipe there is an opening for connecting the cross-head. A maximum of 14 - 4-inch pipes may be used on each header line, the balance being 6 inches to keep up the pressure.

Thawing Equipment.

The following list of equipment for 2 - 13- line thawing units to be handled as one setup will be used by a company that I have been doing some consulting work for, and the prices are of February 1, 1937. These units will each handle a unit of ground 250 by 200 feet, and 10 to 15 feet in depth. The thaw points will be spaced on 10 by 11 feet centers instead of the regular 16-foot spacing. Where ground to be thawed is shallow, this will be found to be the cheapest method. Ten days should be sufficient time for the ground to thaw and with this shallow ground the men should be able to drive around 20 feet per hour. Eight men will be required to handle the points. A diesel-centrifugal pump unit pumping 4500 gallons against a 40-foot head will be used for water supply.

Pieces	Equipment	Est. Cost
25	14 gauge slip joint pipe, 14"x20' $1 a ft.	$500.00
2	14 gauge Tee, 14"x14"x14" length of run 24". Side outlet to be furnished with welded steel flange to fit standard 14" gate. @ $15.00	30.00
2	12 gauge flanged Tee, 11"x11"x14" with 11" runs to be furnished with welded steel flanges 11"x17" F&D. Slot holes to straddle center line of side outlet. 14" outlet flanged to fit standard 14" gate. @ $20.	40.00
10	14 gauge welded pipe 11"x20' to be furnished with 11" by 17" welded steel flange and with 6" flanged coupling welded in at center of pipe. Bolt holes to straddle center line of coupling. @ $1.50	300.00

Pieces	Equipment	Est. Cost
4	14 gauge welded pipe 11"x20' reduced to 8" furnished with 11"x17" welded steel flange F&D with 6" flanged coupling welded in at center of pipe. Bolt holes to straddle center line of coupling. @ $1.50	$120.00
2	14 gauge welded pipe 11"x16' to be furnished with 11" by 17" steel flanges F&D and with 6" flanged coupling welded in at 6' from end of pipe. Bolt holes to straddle center line of coupling. @ $1.50	48.00
8	14 gauge welded pipe 8"x20' to be furnished with 8"x$13\frac{1}{2}$ steel flanges F&D and with 6" flanged coupling welded in at center of pipe. Bolt holes to straddle center line of coupling. @ $1.35	216.00
4	16 gauge welded pipe 8"x10' with blind end welded in. Flanged at open end with 8"x$13\frac{1}{2}$" steel flange F&D. 6" flanged coupling welded in at 6" from blind end. Bolt holes to straddle center line of flange coupling. @ $1.35	54.00
26	6" gate valves @ $36.00	836.00
26	6"x4' Flanged stubs with welded steel flanges to fit flanged feeder line and with 2 wiring lugs spaced 180 on slip joint end. @ $8.00	208.00
130	16 gauge 6"x20' slip joint pipe. To be furnished with 2" std. screwed couplings welded in at 5' from each end of the pipe, and with 2 wiring lugs spaced 180° near each end of pipe. @ $.65 ft.	1690.00
130	16 gauge 4"x20' slip joint pipe. Complete same as above item. @ $.40 ft.	1040.00
26	16 gauge reducers not over 3 feet long. 6" slip end to 4" slip end with 2 wiring lugs on each end spaced 180°. @ $1.50	39.00

Pieces	Equipment		Est. Cost
26	16 gauge reducers not over 3' long 4" slip end to 2" std. black iron nipple. 2 wiring lugs on slip end.	@ $1.50	39.00
26	2" iron cocks	@ $3.50	91.00
2	14" gates for connection between flange feeder line and main line.	@ $125.00	250.00
			$5,301.00

Point assembly cost for ground maximum depth 15 feet.

Ex. Heavy pipe 9.72¢ ft.	-10' lengths	.972
Ex. Heavy pipe 9.72¢ ft.	- 5' ext.	.486
Points bits 32¢ each		.32
Welding bits to pipe12¢ each		.12
Heavy recessed couplings @20¢ each, 2 req.		.40
Pneumatic Hose couplings) 1 Male threaded 1" and) 1 non-slip hose connection)	@ $1.10 set	1.10
Hose 2 ply @ 16.64¢ a ft. 15 ft. each point		2.52
Gooseneck	@ 25¢ each	.25
		5.948

Note: Points are tempered, and pipe cut and threaded at prices quoted above.

Cross Head Assembly.

1 - 2" x 1" Tee) 1 - 2" x 3" Black nipple) 2 - 1" x 6" " ")	@ 66¢ set	.66
2 - 1" iron cocks @ 96¢ each		1.92
		2.58

1000	10' points with 5' extensions with assembly as above.	@ $5.948	$5,948.00
500	Cross Head assemblies as above.	@ $2.58	1,238.00
			7,238.00 ?

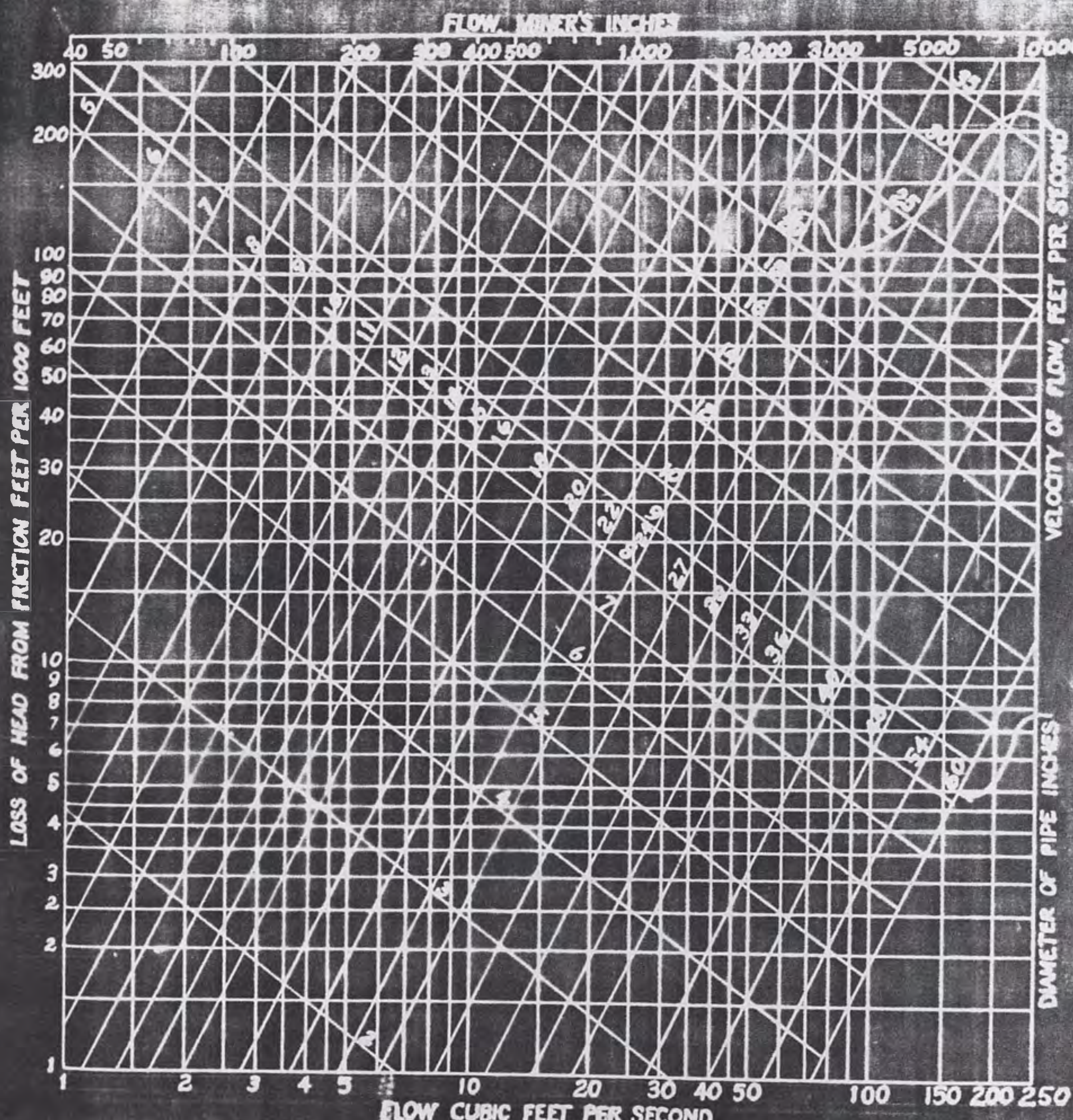
Additional Equipment Necessary.

100	Recessed couplings
25	Hose connections--male threaded
25	" " non-slip
6	15° Ells 6"
6	15° Ells 4"
6	6" Blind flanges
3	8" Blind flanges
2	11" Blind flanges
2	14" Blind flanges
24	18" Walworth pipe wrenches (@ $1.60 each)
3	Coils # 10 Soft black iron wire.
2	Wire clamping tools
8	Sets driving hammers, anvils and clamps.
1	Set Toledo pipe dies.

Use of Pipe Line Chart.

Selection of diameter of pipe line for given flow of water:

The chart shown will assist one in making a choice of the diameter of pipe to be used in any given line. As an example, say that 320 miner's inches or 8 cubic feet per second of water is available under a 100 foot head, and the pipe line is to be 1,200 feet long. The use of 3 sizes preferable because of the saving to be made in freight on the pipe. To solve, start at the bottom of the chart on line 8 and follow it up to where it intersects diagonal lines representing different diameters of pipe. By following the horizontal lines from these intersections to the left margin the friction-head loss may be noted for each diameter pipe. With 12-inch pipe the loss is 80 feet per 1000 feet, which would indicate that little if any pipe of this diameter should be used in the supply line. The loss with 14-inch pipe is 33 feet per 1000 feet of line. If 400 feet of this diameter pipe were used in the line, the loss of head would be 13 feet. With 15-inch pipe the loss per 1,000 feet would be 23 feet and with 16-inch pipe, 16 feet. The losses for 400 feet of these two sizes would be 9 and 6 feet respectively. With 18-inch pipe the loss would be 8 feet per 1,000 or 3 feet per each 400 feet. The total loss of head with 400 feet each of 14-, 16-, and 18-inch pipe would be 22 feet. The effective head, therefore, would be about 78% of the actual head. By using 18-inch pipe the total loss of head would only be about 10 feet. If the gravel is easy to cut and need not be swept long distances,


FLOW, MINER'S INCHES
LOSS OF HEAD FROM FRICTION FEET PER 1000 FEET
VELOCITY OF FLOW, FEET PER SECOND
DIAMETER OF PIPE INCHES
FLOW CUBIC FEET PER SECOND
40 50 100 200 300 400 500 1,000 2,000 3,000 5000 10000
300 200 100 90 80 70 60 50 40 30 20 10 9 8 7 6 5 4 3 2 1
1 2 3 4 5 10 20 30 40 50 100 150 200 250

a 22-foot head loss may not be serious. In tight gravel, however, it probably would be economical to use just the 16-inch and 18-inch diameters, or possibly to construct the whole line of 18-inch pipe. If the total available head were 200 feet, the smaller pipe probably would prove satisfactory, as the percentage of loss would only be one half as much as with a 100-foot head.

Therefore, larger-diameter pipe is needed for long lines than for short ones as the loss of head is directly proportional to the length of the lines. Moreover, where the loss of head is important, relatively larger pipe must be used. If the pipe is dented, rusted, or poorly laid, possibly less water would flow through a given pipe than is shown on the chart. In new straight pipe probably the flow would be more than is indicated on the chart as it has been drawn to cover average conditions.

OPEN CUT MINING WITH THE AID OF DRAGLINE

One method of mining that has come into its own in Alaska during the past two years is draglining, as it is commonly called, with the aid of Bulldozers.

The following is a plant layout that I worked out two years ago while serving as a placer mining expert for the Fairbanks Exploration Department of the United State Smelting, Refining, and Mining Co. Since then several plants have been started and have proved that my costs and yardage figures are about average.

1 Bucyrus Dragline Excavator.
Type 37-B, equipped with 60-foot boom (duralumin), 6 cylinder caterpillar diesel engine, Kohler electric light plant, caterpillar mountings, counter weights, etc. 2 Omaha buckets of $1\frac{1}{2}$ cu. yard each.

Dismantled, crated, and skidded for shipment.
Shipping weight 45 tons. F.O.B. Seattle $22,151.00

1 Pumping unit for sluicing.
12" x 10" Type S.H. Allis-Chalmers centrifugal pump, capacity 3500 gallons per minute under 80' head at 820 r.p.m. F.O.B. Seattle 967.50

Model D. 1100 Caterpillar Diesel power unit, directly connected to pump, whole unit mounted on a structural steel base, skidded and shod.

Shipping weight $12\frac{1}{2}$ tons. F.O.B. Seattle	3840.00
	$ 4807.50

1 Tractor and Bulldozer.

Caterpillar Diesel Model 50	5185.00
Issacson bulldozer model B-50D. with all fittings, and attached to tractor.	1570.00
Shipping weight 14 tons. F.O.B. Seattle	$6755.00

Washing Plant

Trestle material and framing	$700.00
12 Sluice boxes 10'x30"x24" built of 11 gauge steel, welded construction, at $34 each	408.00
Dump Box of 11 gauge steel, welded construction 24' long, 12' wide, 6' high	300.00
10 tailings boxes, 10'x24"x18", built of 11 gauge steel, at $11.00 each	110.00
32# rails for riffles including cost of cutting same	300.00
1 No. 2 Giant	185.00
500' Hydraulic pipe 12" diam. 16 gauge	336.00
500' " " 14" diam. 16 "	364.00
500' " " 16" " 16 "	385.00
Elbows, reducers, gate valves, etc.	300.00
Shipping weight 30 tons F.O.B. Seattle	$3384.00

1 Pump for cutting drains.
24 H.P. Diesel engine connected to centrifugal pump with a capacity of 1000 G.P.M. under a 30-foot head.

Shipping weight 5 tons. F.O.B. Seattle $2500.00

Freight from Seattle to Fairbanks:

Dragline	45. tons	
Pump unit	12.5 "	
Tractor & Bulldozer	14. "	
Wash plant	30. "	
Small pump unit	5. "	
	106.5 tons @ $30	$3195.00

Installation.

Haulage from Fairbanks to 22 Goldstream, erecting and setting up entire equipment, crew of 12 men, 15 days and tractor operation for 15 days.	2041.50
Rental of welding machine	200.00
Wagon and Truck rental	200.00
	$2441.50

Thawing plant.

Thawing 180,000 cubic yards per season with one setting, as this ground is over 30 feet in depth and a growth forms in the pipe in this particular valley and this is all that can expected.

Using 200 cubic yards to a point, would require 900 points.

Cost of complete point for this depth of ground $7.90 each, 7.90x900	$7110.00	
450 Cross Heads @ $3.00 each	1350.00	
1500 ft. of 14-inch diam. Hydraulic pipe	1500.00	
4000 ft. 4-inch header pipe @ 40¢ ft.	1600.00	
4000 ft. 6-inch header pipe @ 60¢ ft.	2400.00	
Valves, elbows and fittings	750.00	
1 12"x10" pump with Model D. 1100 Catarpillar Diesel engine	5250.00	
	$19960.00	

Expense of Mining.

2 dragline operators @	$12.00	$ 24.00	
2 point men @	9.00	18.00	
4 dumpbox men @	9.50	38.00	
2 foremen @	12.00	24.00	
1 shopman @	12.00	12.00	
2 Cat. drivers @	12.00	24.00	
2 handy men @	8.00	16.00	
			$168.00

Dragline operation.

$4\frac{1}{2}$ gallons fuel per hour @ 22¢ gal. for 20 hrs.	19.80	
$1\frac{1}{2}$ gallons of Lub. oil @ 75¢ gallon	1.12	
Other oil and grease	.25	
		$ 21.92

Pumping plant.

5 gallons of fuel oil per hour @ 22¢ gal. for 20 hrs.	22.00	
$1\frac{1}{2}$ gallons of lubricating oil @ 75¢ gallon	1.12	
Other oil and grease	.25	
		$ 23.37

Caterpillar and Bulldozer

3 gallons of fuel oil per hour, 20 hours @ 22¢	13.20	
1 gallon lubricating oil @ 75¢	.75	
Other oil and grease	.75	
		$ 14.70

Repairs

Material used per day	6.00	
		$ 6.00

Pump for Drain cutting and other washing

$1\frac{1}{2}$ gallons fuel oil per hour at 22¢, 24 hr. day	7.92	
Lubricating oil and grease	1.00	
		$ 8.92

Maintenance per season

Cable	$480.00	
Brakes & Misc.	75.00	
Repairs of Caterpillar, pumps, etc.	200.00	$735.00

Average daily output in cubic yards.

Excavator capacity, normal speed, good digging conditions in 24 hours 1500 cu. yds.

Less:	4.35	lost time for moving washing plant, etc.
	3.33	lost time for cleanups.
	7.68%	Total lost time.

1500 cubic yards less 7.68% equals 1285 cu. yds.

Labor expense per day of 20 hours	$ 168.00
Excavator expense per day,20 hours	21.92
Pumping plant expense per day, 20 hours	23.37
Cat. and Bulldozer expense per day, 20 hours	14.70
General repairs	6.00
Cut drainage expense per day, 24 hours	8.90
Daily expense	$ 242.89

Equipment valued at landed cost	$45,170.00
Depreciation @ 15%	6,775.50
Season of 150 days	

242.89 ÷ 1285	= $ .1890	per cubic yard
plus maintenance and depreciation	.0390	
Gravel Mining costs.	$ .2280	per cubic yard.

Bunk and Mess House.

No charge is made for the above item as it is taken care of in the labor charge. All wages in this part of Alaska include board and room. Men who work on contract are usually charged $2.25 per day for board alone.

Stripping and Thawing Costs.

Using an average cost of ten cents per cubic yard charged against the gravel content of the deposit, the total mining cost of this type of mining in deep ground will be about 33 cents per cubic yard, which has proved to be a fair cost.

Explanation of Plant Operation.

Fig. 26 shows the Dragline in operation and Fig. 25 the setup of mud box and sluice with tailing disposal.

The sluice boxes are set on a trestle in this type of operation to allow the tailings to flow away from the end of the boxes without other mechanical aid. The last few boxes are placed on a overhang which is supported by means of trusses and cables as shown in Fig. 25;this setup allows a large amount of tailings to flow back under the dump without burying the trestle bents. Although it has been found in actual practice that the first two bents will have a few feet of gravel around them.

Fig. 28 illustrates the method of placing the tailings sluices after the tailings pile has reached the height of the trestle. These boxes are added from time to time to carry the tailings further away from the sluice. Better operations are possible if a splitter is placed just below the end sluice box so the tails can be shifted to either of the two tailings boxes. Trying to place a new tailings box in the stream is a very hard operation and requires from 2 to 3 men; by aid of the splitter one man can handle the job without difficulty.

Fig. 27 illustrates the method of washing the gravel with the aid of a giant placed at the lower end of the "dump" or "mud" box. One man is also needed at this point to rake the material and help keep it moving. Half of the water is used at the giant and the other half is fed into the head of the box.

Fig. 29 illustrates a pumping plant consisting of a Caterpillar diesel engine directly connected to a 12" by 14" single-

Fig. 25.
Trestle supporting mudbox, sluice and hydraulic giant for washing the gravel. Dragline bucket in position for dumping.

Fig. 26.
Dragline in operation. Note the way the Bulldozer has cleaned the bedrock in front of the dragline.

Fig.27.
Dragline dumping a load of gravel. Nozzel man and helper working the gold bearing material.

Fig. 28.
Sluice with 6 sections of tailings boxes in place. As pile grows more boxes will be added.

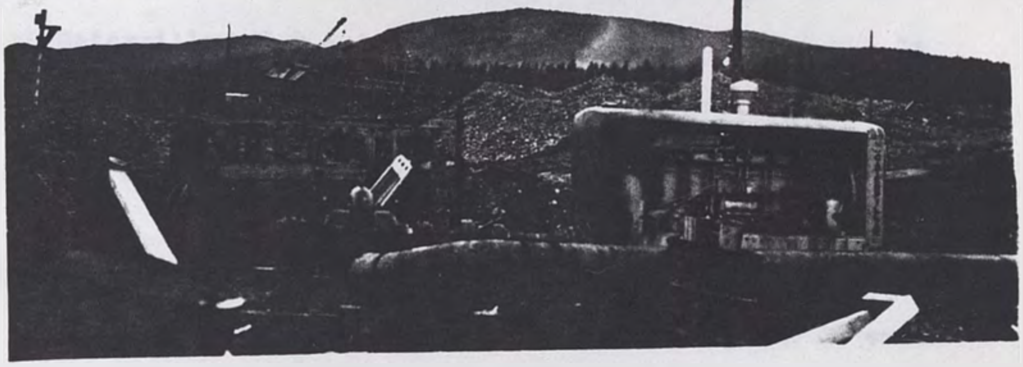


Fig. 29.
Diesel-centrifugal pump unit in operation. Note washing plant in background.

Fig. 30.
RD-8 Caterpillar and Issacson bulldozer moving gravel into position for dragline. This unit has no trouble in removing from 1 to 2 feet of bedrock.

stage centrifugal pump. This particular unit will handle 4000 gallons per minute against a 80-foot head. The dam for this work is placed in the same position as was mentioned under thawing and for the same reason.

Fig. 30 illustrates a Caterpillar tractor used for pushing gravel and about one foot of bedrock over to the dragline for elevating to the sluice. This particular unit consists of a RD8 Caterpillar with a 14-foot blade Issacson Bulldozer. It has no difficulty in supplying the dragline with more material than it can handle.

Proposed New Development.

After studying the operation of the above plant it seems to me that 2 or 3 hundred cubic yards per day may easily be added to the plants operation by placing the dragline at the end of the sluice boxes. The boxes will be placed in bedrock, the bulldozing unit will shove the material to the head box where it will be washed into the boxes by aid of a giant. The dragline being placed at the end of the boxes will not have to stop on the dumping cycle for spotting of the bucket and will be able to make more swings per hour. Also, when elevating the unwashed gravel, care has to be exercised in not allowing spill, due to the loss of gold, into the worked area. I have received assurance that this will be tried this spring and feel sure that, once tried, it will be used continually.

Stripping of Moss and Brush with Caterpillar and Bulldozer.

While most of the moss stripping is carried on in this district in the manner discussed under ground sluicing, the time and cost of doing this work may be reduced to less than a quarter of the former cost with the aid of a large caterpillar and bulldozer. But instead of doing the work during the month of August when the maximum thaw is in the ground, it should be done early in the spring when the thaw is only a few inches deep. Working with a crew of 3 men, with one man as cat. driver and two men stacking and burning, no trouble is experienced in clearing 10,000 square feet per hour.

Other Types of Open-cut Mining.

The cheapest method of open-cut mining from a equipment standpoint is of course shoveling in. This method is exceedingly primitive. The gravel is loosened by means of pick and shovel and transported by wheelbarrows pushed along on planks laid on bedrock. It may be then dumped into a bucket and hoisted to the dump-box at the head of the sluice or, in some cases, into a car which is hauled up an incline and dumped into the dump-box. Occasionally the grade of the bedrock is such that the boxes can be set up in the center of the cut and the wheelbarrows unloaded directly into the boxes.

Shoveling in is slow and costly and only suited to extremely rich, shallow deposits.

Scrapers.

Another method of excavating is with a scraper outfit. The most primitive method is the one in which a horse-drawn scraper is used to gather the gravels and convey them to a carrier bucket or to a driveway built so that the load can be dumped directly into the boxes. This type of scraper requires three men in constant attendance, two men to ride the scraper in order to make it dig properly and one man to drive the horse or horses. Even with more than one scraper operating at a time this method is slow and costly. A large crew is needed and the maintenance of the horses is expensive.

Mechanically Drawn Scrapers.

Fig. 31 illustrates a mechanical carry-all or scraper for operation behind a caterpillar. This type of unit, while much faster than any other type of scraper, is a great deal slower than a bulldozing unit.

Other types of mechanical scrapers moved by means of cables have disappeared from this district and will not be discussed in this paper, except for tailings-stacking purposes, under hydraulicking.

Fig. 31.
10 cubic yard carry-all, proved to be a failure on placer work.

Fig. 32.
Prospector moving camp during the summer season. This outfit has proved very successful in a country free of "nigger-heads" and large boulders.

HYDRAULICKING

Hydraulicking on a large scale has not been developed in the Fairbanks region. Scant water supply and gently sloping bedrock are largely responsible for this. Hydraulicking on a small scale, however, is a favorite method of mining. In the Fairbanks region hydraulic operations can only be carried on during the spring when sufficient water is available. At other times most of the water must be pumped.

Pumping Plants.

While several different pumping plants are in operation, one is of especial interest and will be described to bring out several points that must be kept in mind in designing a plant of this type. The following plant is located on the Chena Slough and elevates the water over a low range of hills to the mining operations on the other side.

Figs. 33 and 34 illustrate the inside of the plant while Fig. 35 shows the intake screen used to remove any debris from the water.

Each pumping unit consists of 2--220-foot head single stage centrifugal pumps connected in tandem. Each pump is driven by a 400 hp. synchronous motor, revolving at 1200 r.p.m. The rated capacity of each unit is 6000 gallons per minute against a head of 440 feet. The lift is only 400 feet and the other 40 feet takes care of pipe friction.

Fig. 33.
Switchboard for 5- 800 h.p. pumping units.

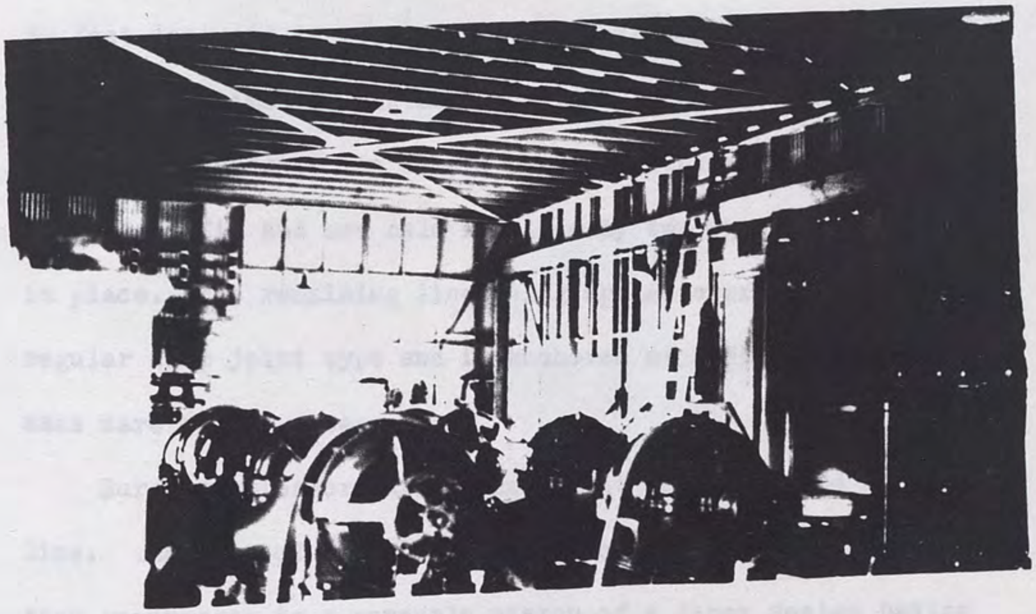


Fig. 34.
Pumps used for elevating water over a 400 foot hill for mining purposes.

2 units discharge into a single pipe of 26-inch diameter. The suction of each unit is well submerged and has a bell-shaped opening which keeps the entrance velocity below the required value. No foot valve is used due to the friction loss in this type of construction and the pumps are primed with the aid of vacuum pumps. On the outside of the plant and shown in Fig. 36 is coupled a Chapman Non-Slow Check valve of the float type, on the other side of the valve is placed a rising stem hand gate. The check valves are necessary in the advent of a power to keep the pumps from reversing themselves and attaining such a speed that they would fail. The rising stem gates are closed in starting and shutting down a unit to lessen the jar on the pipe line.

The main lines are about 3800 feet long. From the pumping station to the foot of the hill, a distance of about 1500 feet, the pipe line is of the Dresser Sleeve type. Each section is 30 feet long and is brought up to within a fraction of an inch of the next similar length. A metal sleeve fits over the joint and the two ends of the sleeve are sealed by rings of rubber tapered to fit and are held in place by two iron rings bolted in place. The remaining line going up and over the hill is of regular slip joint type and is anchored at suitable points to take care of any creep.

Surge suppressors are connected at the lower end of the line. They are of very heavy construction. On the inside of each suppressor is a moveable piston of a taper design having the larger end at the back end away from the line. This piston is kept closed by means of water pressure delivered by means of

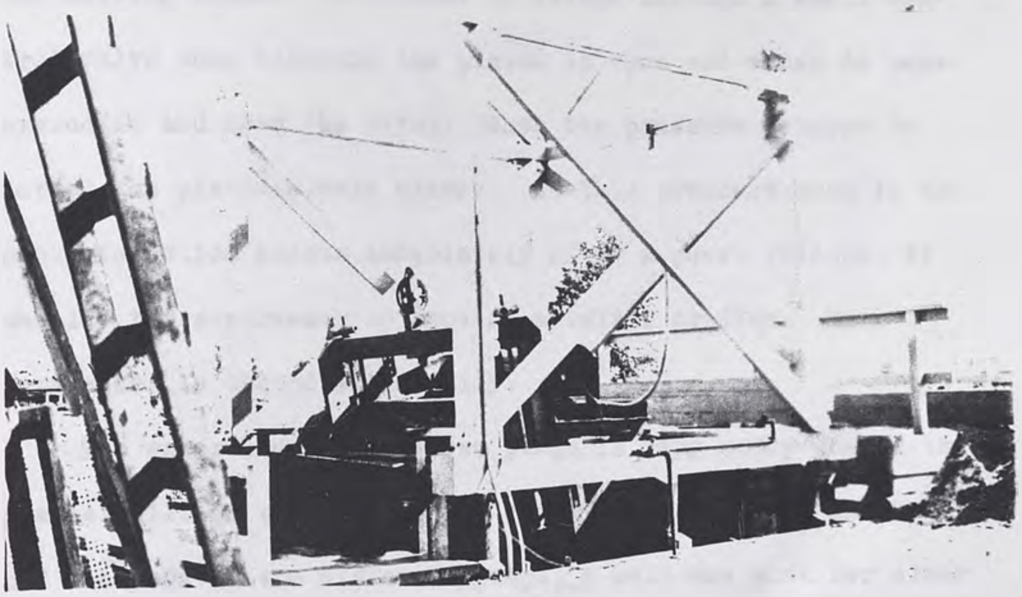


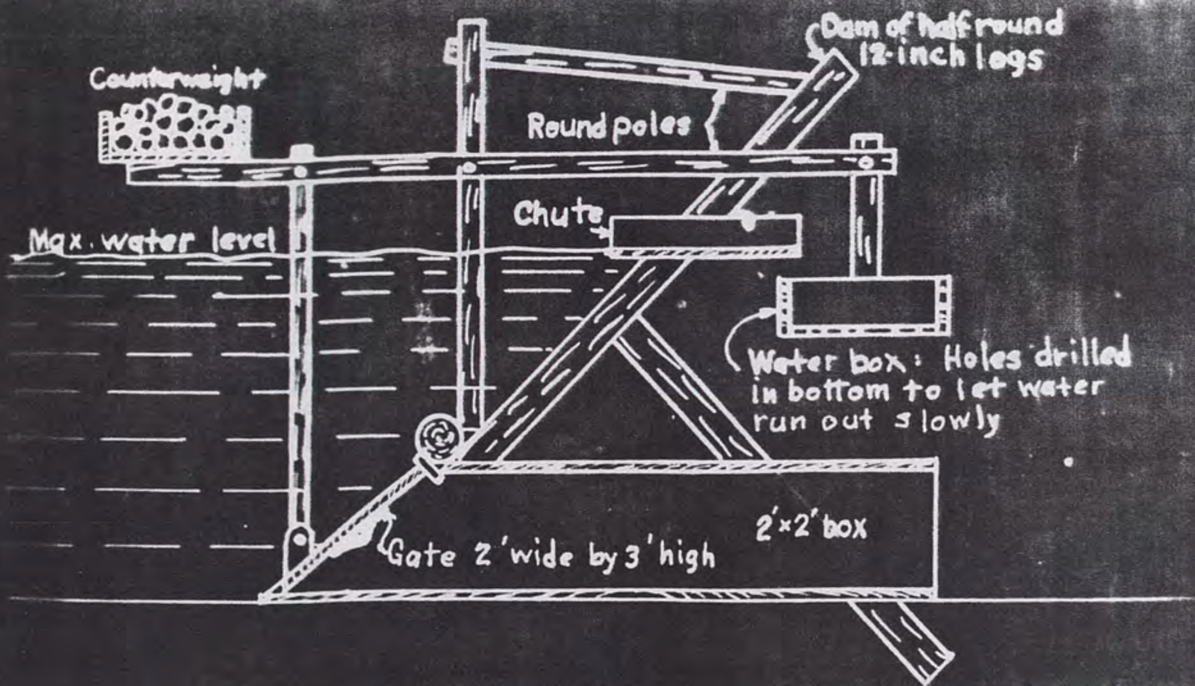
Fig. 35.
Type of moving screen that has proved very satisfactory for cleaning water before pump intake.

Fig. 36.
Surge suppressors and pipe line.

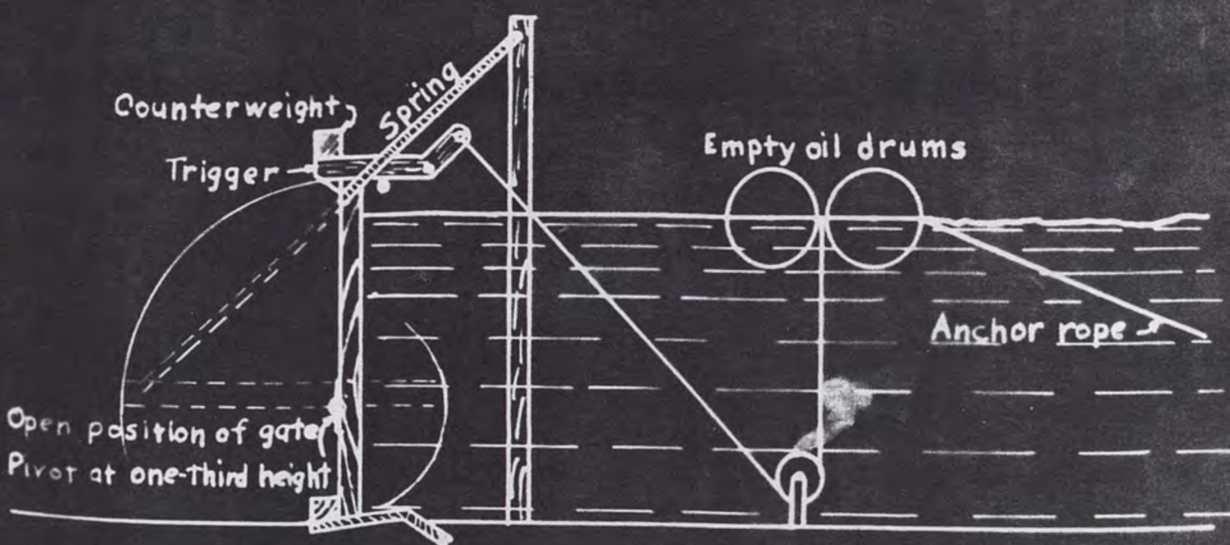
auxilary pumps. By means of an adjustment on the suppressor, whenever the pressure drops below a set value the water from the closing chamber is allowed to escape through a small control valve thus allowing the piston to open and water to pass around it and into the river. When the pressure returns to normal the piston slowly closes. As this pressure drop is the condition which exists immediately after a power failure, it enables the suppressor to provide a relief orifice. Each suppressor is tested twice daily.

The water handled by these pumps is very muddy due to the glacier silt in the stream. In order to protect the shafts and bearings on the different pumps, a well was sunk for clear water and this is supplied to the packing rings of the main pumps, besides furnishing water for a seal to the vacuum pumps used in priming. These vacuum pumps are of the rotary type. Each one has an evacuating capacity of 21.8 cubic feet of air per minute.

Benches are worked by means of water streams thrown through giants (or nozzeling) against a bank from a point below. Creek deposits are often worked by means of dams equiped with automatic gates. Two types of these automatic gates are illustrated in Figs. 37 and 38; while these two illustrations are taken from Montana practice, the Fairbanks gates are constructed on the same principle. When the dam is filled, the water overflows into a small box or barrel which, when full, is heavy enough to trip the release of the gate and allow the water to escape. A small opening in the bottom of the tripping box allows the



A



B

Two types of automac gates for booming A. Gate used at Bennet mine, Rivulet, Mont. B. gate used at Harvey mine Lincoln Mont.

H.

water to escape from it while the dam is being emptied. This opening must be large enough in size so when the dam is empty the weight of the box and contents will not be sufficient to keep the gate open. The gate closes and the dam is ready for refilling.

In this manner the water comes down at regular intervals and with sufficient force to be of some use. In the interval while the dam is being filled, rocks and boulders are piled to one side and the cut is prepared for the next rush or "boom."

In deep narrow valleys, hydraulicking can be carried on by means of ditches or pipe lines. The slope of bedrock in this type of creek is much steeper than that of the broader valleys, and due to the narrowness, less ditch has to be built or less pipe line laid.

In order that hydraulicking may be successful the ground should be shallow with a minimum amount of overburden. The bed-rock should be smooth and firm. Large boulders are a drawback as they have to be removed by blasting or hoisting.

Fig. 39 and Fig. 40 illustrate a hydraulic setup in a narrow valley. Fig. 39 shows the head or washing giant sweeping the pay gravels into the sluice boxes. Wing dams are constructed at the head of the boxes to divert all of the gravel into the boxes. The boxes should if at all possible be set into the bed-rock. This will give less gold loss and has made the difference between profit and loss on several creeks. Fig. 40 shows a tailings giant in operation. This giant is placed at the lower end of the sluice boxes and the tailings are blown to the side

Fig. 39.
Hydraulic cut, showing giant at head of cut with giant used for stacking tailings below the sluice.

Fig. 40.
Giant "blowing" tailings.

of the cut. This giant may use over half of the water present on the creek.

Fig. 41 illustrates a hydraulic setup in another valley. The method of bringing the water by means of pipe from the side hill is shown. The large rocks on either side of the string of boxes have been removed from the cut by hand methods.

Fig. 42 illustrates a sluice box during the clean-up. Sluice boxes are usually placed on either a 10 or 14 inch grade in this section. Most operators favor the 12 inch drop per sluice box length as they claim they can save more gold by this method. While this is contrary to most authors of placer mining handbooks it seems to work out that way in this section.

Figs. 43 and 44 represent a hydraulic setup in a slightly wider valley. This valley is too wide for a single sluice and is just the right width for a double cut. By using this method no water loss is possible. As soon as one cut is completed another one on the other side of the valley is all set up and the gravel is washed into the sluice boxes. Fig. 43 shows one side of the valley with the cut completed, wing dams removed and the men cleaning bedrock by hand and removing the gold from the boxes. Fig. 44 shows a wing dam in place in front of the boxes. In the lower foreground of this illustration will be noted the opening to the boxes and iron sheets are shown on each side to protect the planking where the maximum wash takes place. These dams are built high to prevent any gravel from flying over the dam.

Fig. 47 illustrates hydraulic mining with the aid of giants and the cleaning of the bedrock by means of a caterpillar and bulldozer.

Fig. 41.
Hydraulic cut, showing pipeline setup, with sluice boxes and large boulders which are removed from cut before they reach the boxes.

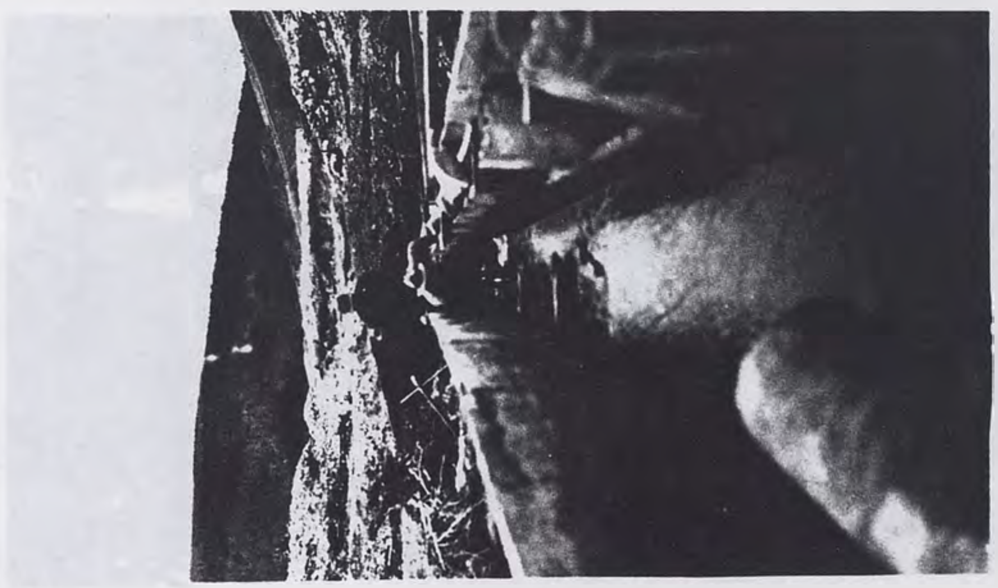


Fig. 42.
The end of a clean-up.

Fig. 43.
Finishing a cut and cleaning up, men shoveling bedrock into sluice.

Fig. 44.
Wing dam in position and ready to start a new cut.

Fig. 47 shows a giant in the back ground with the caterpillar and bulldozer in the foreground shoving a load of gravel up to the head box.

Fig. 46 illustrates a sluice box with a man at the head end with a rake to keep large material and brush moving down the sluice.

Fig. 45 illustrates a tailings disposal system, a slackline cableway carrier just coming out of the dump where it is loaded with a load of tailings and is then hoisted to a Gin-Pole as shown in Fig. 48 where it is dumped.

Drift Mining.

Drift mining is that system of mining in which the surface of the ground is left undisturbed as much as possible and only the gravel next to the bedrock is extracted.

Drift mining originated in California where the method was used to extract the cemented gravels of the ancient river channels. In Alaska different conditions have to be met. Frozen gravels are encountered and they have to be thawed or blasted before they can be excavated. While the walls and roof remain frozen they stand well over large areas without support, when thawed they turn to unconsolidated gravels which can only be supported with great difficulty. Mining methods must recognize this factor and evolve ways of handling it.

Shafts.

The location of the shaft should be in the lowest part of the area to be worked so ore movement will always be with the grade, better drainage is also afforded. The shaft should be about 7

Fig. 45.
Removing tailings with the aid of a slackline cableway.

Fig. 46.
Sluice boxes.

Fig. 47.
Bulldozer cleaning bedrock in a hydraulic cut.

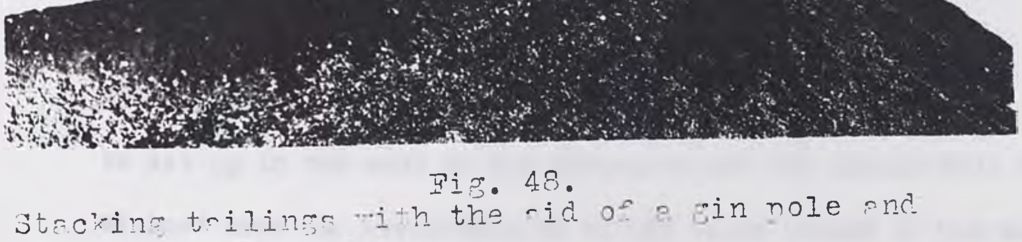


Fig. 48.
Stacking tailings with the aid of a gin pole and slackline cableway.

by 7 feet in the clear so a large size bucket may be used and still leave plenty of room for steam, water and air lines. Shafts should be cribbed tight with brush placed behind the timber to keep any thawed material from sloughing into the shaft. If the shafts are put down during the winter they do not have to be cribbed until the following spring before the thaw. The timber starts at the bottom of the shaft and is very easy to install.

Drifts.

From the bottom of the shaft a drift is run upgrade until it reaches the limit of the pay or the end line of the claim, although this distance rarely exceeds 500 or 600 feet. Cross-cuts are driven 200 feet in each direction from the drift. Then a regular long-wall retreating system of mining is employed, working the gravel towards the shaft and only using enough timber to hold the back up where the men are digging. As the men retreat toward the shaft the tools and blocks are removed from the worked out area and it is allowed to cave.

A modification of the above is to be tried out in this district in the near future. The development workings are being driven the same as the above. All material in this mine is being removed by drilling with air drills and blasting. The pay occurs in the first foot of gravel so 5 to 6 feet of bedrock are removed along with 2 feet of gravel. When the development work is completed, high pressure nozzels will be set up in the ends of the crosscuts and the gravel will be sluiced down the cross-cuts to sluice boxes placed in the main drift. The tailings from the sluice boxes will flow into a settling basin at one side where the water will be repumped for sluicing, the sands and gravel settling out will be loaded by means of slusher scrapers into skips for elevating to the surface. The drilling and blasting of the ground has proven much cheaper than the regular method of steam thawing the gravels.

I do not have a great deal of faith in the success of this operation, due to the large load of fine material in the water. This will cause an excessive wear on runners and shafts even if some type of hydroseal pump is used. By using a mechanical loader, such as, the EIMCO, gravity plane haulage system and with the sluice boxes on the surface, the mining costs should be lowered. Average costs in this district have averaged between 75 and 90 cents per square foot of bedrock.

Hoisting.

Automatic dumping devices are usually used in connection with the hoisting. A bridle is affixed to the bucket and runs on a separate cable. The bucket is free to swing in one direction on the bail but is balanced so it will not overturn unless outside force is applied. The bridle cable is fastened at the top of the gin-pole and anchored at the bottom of the shaft. A stop placed on this rope stops the ring on the bridle and supplies the force necessary to overturn the bucket. This stop is moveable along the bridle rope so the point of dumping may be controlled. Fig. 49 illustrates the carrier and bucket used.

The carriers used in this type of hoisting are all important and are a development of interior Alaska. They provide an efficient

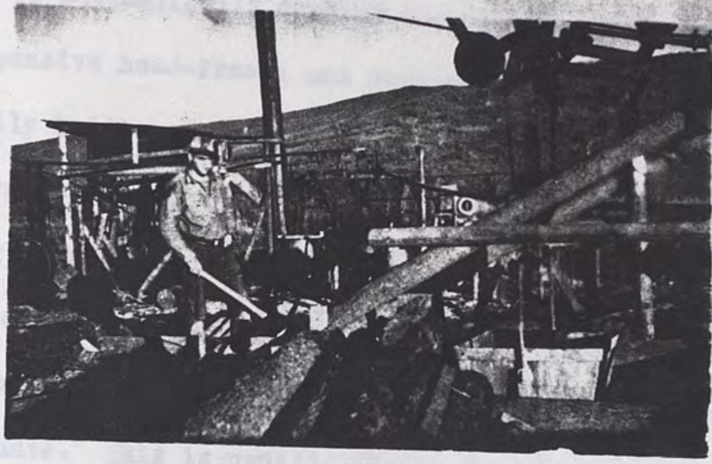


Fig. 49.
Carrier and bucket, used in drift mining.

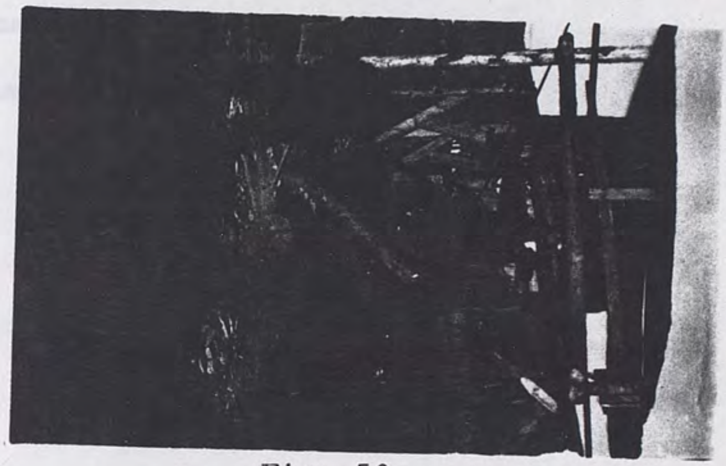


Fig. 50.
Steam hoist for above plant.

Fig. 51.
Thaw field showing header pipes and cross-heads.

means of automatically dumping the dirt without the installation of expensive head-frames and cumbersome machinery. They are sturdily built and breakage is slight. Springs or light steel members which would tend to become unduly brittle and snap off during cold weather are avoided so all parts are of heavy and durable construction. High speed can be developed with these carriers, the round trip from a 60-foot shaft requiring about one minute. This is usually faster than the dirt can be supplied to the bucket at most of the mines.

The type of bucket used in drift mining are usually shallow, approximately 4 feet by 4 feet and 2 feet deep.

D R E D G I N G

Many freakish designs of dredges have been made with the hopes of constructing a unit that would handle odd deposits of gravel that could not be handled by any other method. Figs. 52 and 53 illustrate one of these dry land dredges built in the Fairbanks district by an expert mechanic. This dredge is almost entirely constructed of old automobile and tractor parts. It was built with the hopes of dredging some steep deposits, with a minimum amount of water, but like many such dreams, proved a failure.

The only successful type of gold dredge operating in the interior is of the bucket line type. These dredges may be classified by the manner in which they treat the gravels. (1) flume, (2) screen and flume, (3) combination, (4) stacker. The type of dredge used in this district is of the close connected stacker type. This is the type that will be taken up in this paper.

On the open connected bucket line dredge, the buckets are held in the line by links from the back eye of one bucket to the front eye of the next. Formerly, this type of bucket line was recommended for digging difficult bedrock and ground containing many boulders, since the buckets on a close connected line are occasionally broken when a large boulder is squeezed in between them. However, proper design of the buckets will obviate this

Fig. 52.
Digging end of a dry land dredge.

Fig. 53.
Stacker end of the same dredge.

difficulty, leaving little advantage to the open connected type. The only application of the open connected line is on the very small dredge digging shallow ground. Here, its lightness and lower cost permit its use.

Bucket Line.

The bucket line is really the life of the dredge as the dredge capacity is entirely dependent upon the amount of gravel the buckets dig. It must be correctly designed for the type of material that is to be handled.

In loose ground, large buckets may be used, while if ground is tight and occasional frost is encountered, the buckets must be small and compact.

Very small buckets have generally been used in this district. Two 10-foot dredges; 3-six-foot dredges; 2 four-foot boats, and the rest of smaller size are now being handled successfully. A new dredge is now being designed for a new area in this district and will be of much larger size, and from all indications will be of a new design. The gravel is over a 100 feet deep in some places and is very small, over half of it being in the sand or finer class. Figs. 54 and 55 illustrate the sinking of a 18-inch hole, a vertical distance of over 240 feet to bedrock. The gravels from this hole have had many tests run on them to determine the manner of treating the material on the dredge as well as the method of tailings disposal.

For working ground containing many boulders, the buckets must have low backs to prevent crushing when a large boulder is

Fig. 54.
Keystone drill used for sinking an 18 inch hole to bedrock. Depth of hole 240 feet. 18 inch casing pulled into hole with the aid of hydraulic jacks.

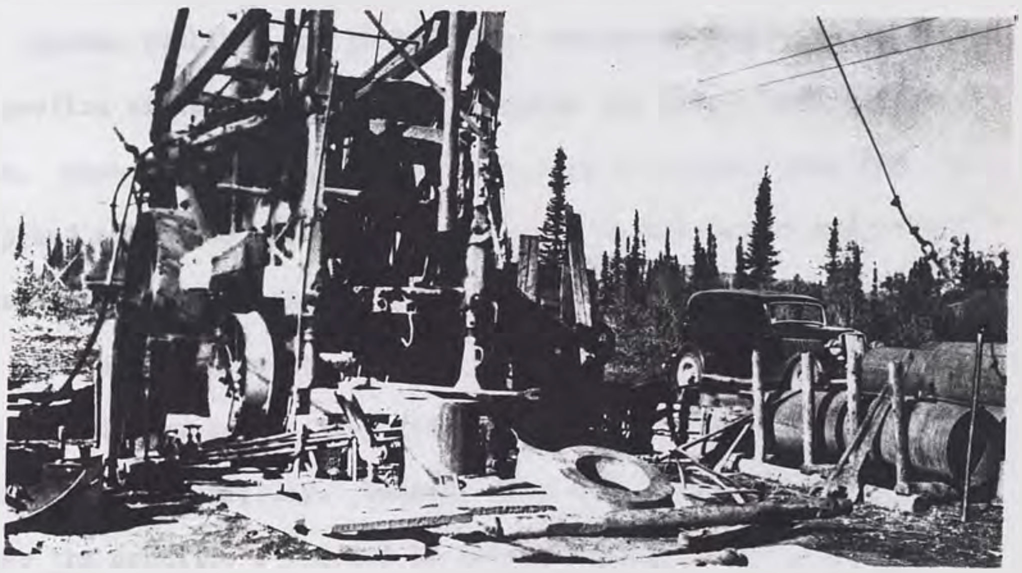


Fig. 55.
Pulling head in the foreground.

caught between two of them. If the gravel is small, deeper buckets may be used.

The height of the lip is usually determined by the character of the digging. If a high bank is carried, a low lip should be used, so that when the buckets are almost horizontal no more material will be dug than what the buckets will carry. If the bank is composed of soft material that caves readily, high lips should be used.

Nearly all the buckets are a single casting of manganese steel having a half circular bushing consisting of two parts in the back eye. Such buckets last about a 1000 dredging days. The life of the bucket might be prolonged with patching around cracks and worn places but usually does not pay.

The bucket pins are usually constructed of nickel-chrome steel as it takes a very good grade of material to stand up under the very severe conditions under which they operate.

Bucket bushings are generally of manganese steel. Frequently inspection of the bushings will lengthen the life of the bucket line. When the bushings become worn thin or broken, they may slip and allow the pins to turn directly on the bucket eye, causing an early discarding of the bucket.

The bucket lips are also of manganese steel. In easily dug ground they have a long life, but frozen or cemented gravel wears them very rapidly. Usually they last about one season under the conditions present in this district.

<u>Main Drive</u>.

The upper tumbler, on most of the recently built dredges, is one piece with the shaft. The buckets seat on heavy wearing plates which are frequently a source of trouble. They carry the load and digging stresses of the bucket line and are subjected to severe shock each time a bucket seats on them. The repeated shocks and abrasive wear caused by slippage of the buckets themselves demand that the plates be made of tough hard steel. At present the most satisfactory plates are made of an alloy steel containing about 11% manganese and some nickel. However, the determining factor in the suitability of the tumbler plate is not so much the percentage of composition, but the heat treatment given by the manufacture.

The upper tumbler is nearly always driven by two large bull gears, one on each side, to prevent torsional strains in the shaft. Two pinions are connected by an equalizer. On some dredges the drive is direct from the motor, but it is probably always advisable to use a belt drive to permit some slippage when the bucket line meets an obstruction.

Dump Hopper.

The buckets dump directly into a hopper which is as large as can be permited by the dimensions of the bull wheels on the upper tumbler. A small hopper would give trouble by allowing large pieces to arch over. The liners in the hopper are made of thick heavy plates of alloy steel. Sometimes a hopper is designed so that discarded bucket pins can be laid in to take the wear. This practice, while economical of steel, may cause difficulties because of the resistance offered by the uneven surface to the passage of the gravel.

It has been found advisable on many dredges to install one or two high pressure nozzels which direct a stream of water against each bucket as it dumps, so as to wash out adhering clay or sticky bedrock. In spite of this precaution, some material is retained on the lips or in the buckets and may be dumped when the buckets come down the lower side of the line. To save the value in this spillage a grizzly is put underneath. Material falling through this grizzly or "save all", as it is called, is washed on small tables underneath it.

Screen.

The material from the hopper passes into a large revolving screen with perforated plates of high carbon or manganese steel. Some of the smaller dredges have tried shaker screens, but since one of the objects of the screen is to break up all lumps, the trommel type is much more suitable. High pressure nozzels direct water either from the end or from a large pipe running parallel with the axis and inside the screen, this later method seems to be the most satisfactory.

The size of openings in the screen increases towards the stern of the boat from 3/8 of an inch to $1\frac{1}{2}$ inches at the lower end. A small grizzly is often put in the chute at the end of the trommel. Material falling through this grizzly goes to a small "nugget sluice" which will catch any gold nuggets too large to go through the screen.

Stacker.

The oversize from the screen is carried on the stacker, a belt conveyor pivoted underneath the screen chute and suspended from the stern gantry. In Alaska the stacker is usually enclosed with a canvas covering, and steam pipes are carried up near the belt. Provision is usually made for shifting the flow of coarse material from the stacker to short chutes which will deposit the gravel near the spuds in case there is difficulty in holding the dredge up to the digging face.

Spuds.

The spuds on very small dredges are sometimes made of wood. However, since the spud takes a very severe strain both in bending as a simple beam and in torsion caused by frictional resistance against turning, and since either spud should be available for digging, modern practice is to use two heavy steel spuds. They are usually built up from steel plates and angles and are better if bolted together rather than riveted, since most of the stress comes on a few rivets which may work loose. The bolts hold better and can be easily tightened when necessary.

The bearing of the spuds against the hull is great and, unless there is a properly designed casting to distribute this force, the hull may fail. Present dredges have the spud bearing against a large casting several feet wide and covering the entire depth of the hull. The Fairbanks dredges after eight years of operations, during which time they have occasionally bucked some hard frost show no sign of failure at the spud supports.

Winches.

The winches for the bow-swing lines, stern-swing lines, spuds, gangplank, and emergency use are all driven by one motor through a system of gears and clutches. The bank of winches is usually on the starboard side. Formerly only one or two speeds were available, but at present the practice is to use a variable speed motor so that the operator may swing rapidly when digging loose ground or more slowly when in tight ground. The variable speed motor is also useful when repairing or changing lines.

The ladder hoist winch may be driven by a separate motor, by the main drive motor, or by the swing winch motor. The latter is probably the least advisable. The arguments for the separate driving motor are: the greater safety if positive gearing of the ladder hoist is employed, so that the ladder must be lowered under power instead of by brakes, and the greater efficiency if the main drive motor is designed only for digging loads. Since it is usually advisable to have the main drive motor with plenty of reserve power, the efficiency is not greatly diminished by having it raise the ladder also.

The wire ropes of a dredge meet severe usage, being dragged through the dirt on the banks and through the water, so they should be of the highest grade obtainable. The ladder hoist and bow-swing lines are nearly always 6x19 plough steel ropes, one inch to $1\frac{1}{2}$ inches in diameter, and the stern-swing and stacker hoist lines, also 6x19, may be either of plough steel or of crucible cast steel.

Wire rope manufactures recommend that sheaves should have a diameter equal to at least 40 times the diameter of the rope. The sheaves on board a dredge usually adhere to this ratio, but shore sheaves are much smaller since they must not be too large to handle.

Cost of Dredge Installation in the Fairbanks District.

Two new dredges are being built in this district at the present time that I have been closely associated with. One is a four foot pontoon stacker dredge, complete with diesel power. This dredge will weigh 450 tons when completed. Under the contract the manufacture will set the dredge up, ready to run, on the property for $145,000. The other boat is of the same type of construction and power and will cost in the neighborhood of $182,000, ready to run.

CONDITIONS AFFECTING DREDGING OPERATIONS

A dredge works at best advantage when in a valley of fair width, low creek grade, and with gravels which are not too deep. If the valley or pay streak in the valley is very narrow, operations will be strung out and the proportionate cost of service roads, power lines and the like will be increased. It also frequently happens that narrow valleys have occasional high bedrock reefs on the sides. While minor rolls in bedrock, so hindersome to drift mining or hydraulicking, do not greatly affect dredging, larger reefs too hard to be dug may make manipulation of the dredge difficult.

A low grade to the creek is usually best for dredging. If the grade should be too steep there is likely to be trouble in keeping water in the pond, making it necessary to build dams.

The depth of gravels has a direct bearing on the size of dredge to install. The digging depth of a dredge may be increased by carrying a rather high bank. This may be done by pumping from the pond or putting in a drain so that a low pond level can be maintained. Some of the larger dredges carry a bank twenty to twenty-five feet high, but to carry such a bank with a small dredge would be dangerous, since the bow of the boat is so close to the bank that a sudden cave-in might cause serious damage.

A plentiful water supply is valuable to a dredge since it enables the operator to keep the pond water clean and free from floating debris. Dirty water wears the pumps readily and lowers the recovery. Fifty miner's inches of water is the minimum amount of fresh water required by the dredges in the Fairbanks district. If the gravel should contain much silt, this minimum would be increased.

A dredge is more easily handled when digging upstream, since the tailings can be so placed as to form effective dams when high water for flotation is desired or a channel can be left, enabling the dredge to carry a high bank. Therefore, where the width between dredging limits is so great as to necessitate more than one advance of the dredge, it is wise to take the most difficult parts of the area on the upstream course.

Pond ice usually starts to form in this district the latter part of September, but does not become a serious problem until late in October. Then it begins to get difficult for a dredge to move from one cut to another. Dredges in shallow ground then have an advantage as they can move rapidly back and forth across the pond, keeping the ice broken. With dredges digging deeper ground, the pond ice may become too thick to buck in one or more of the cuts. Blasting the ice is then the only remedy. The yardage drops with the temperature and shut-downs become more frequent because of conjestion in the ladder pan and because of broken lines.

Practically all the dredges in this section have small boilers to furnish steam to keep the ladder line and stacker free from ice and to keep the pumps open.

Before operations may be resumed in March, it is necessary to remove the ice from the pond. Fig. 51 illustrates the method of cutting the ice. Half-inch pipe is made into the form of a U, a steam line is fastened to the top and holes are drilled in the bottom of the U and at the corners, these U are placed in a slotted frame, the steam turned on and they then cut through the ice. The length of time necessary for the cut of about five feet varies from 2 minutes to as long as 30 minutes, being dependent upon the amount of dirt and gravel in the ice. Cakes are cut 3 by 5 feet and are the thickness of the ice, which will vary from 3 to 5 feet.

After the ice is cut, a high line is put up and the ice is removed as shown in Figures 56 and 58, and placed in large stacks like in Fig. 59. As high as 240 cakes of ice have been removed in a day, but the average is closer to 160.

Fig. 56.
Removing ice from pond with the aid of a high line.

Fig. 57.
Thawing ice with steam. Note method of holding U in place so one man can keep several thaws going at one time.

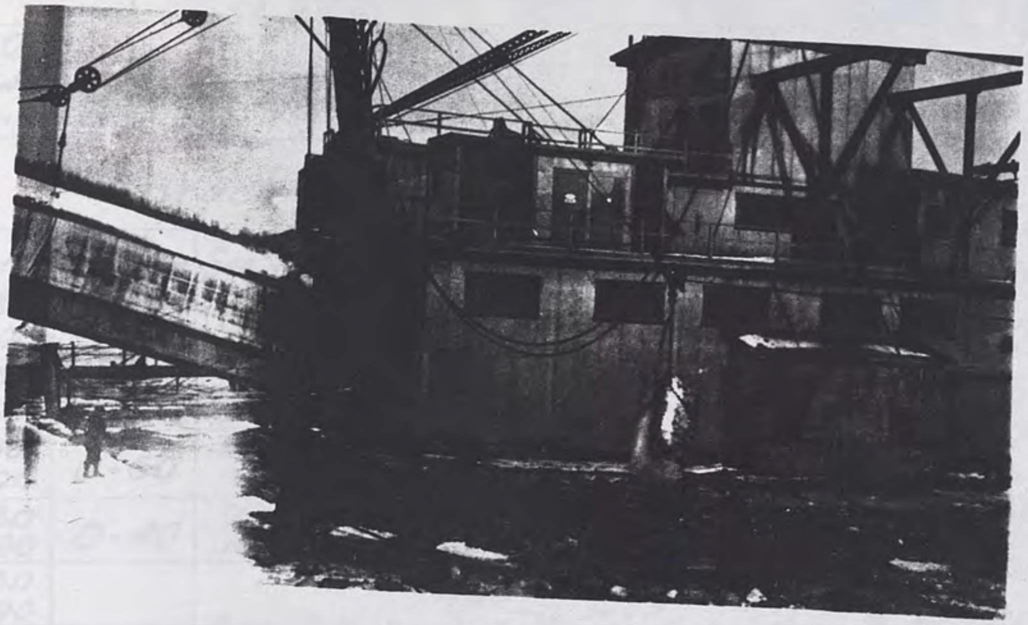


Fig. 58.
Removing a cake of ice from the pond. Note the size of the ice cake compared with the men.

Fig. 59.
Ice pile on the shore of the pond. There may be from 2000 to 3000 cakes of ice in one of these piles.

Standard Bracing Methods

Bracing for No. 2 Giants

Pressure	For temporary set-up use bracing shown by dwg No.	For permanent set-ups use bracing shown by dwg No.
0-60	1 or 2	3 or 4
60-140	2 or 4	3, 4 or 5
Over-140	6 or 7	6 or 7
ups on top pipe	8	8

Bracing For Elbows

Size	Angle	Pressure	See dwg. No.	Pressure	See dwg No.	Pressure	See dwg No.
9"	0-60 60-90	0-110	9 or 10 11 or 12	over 110	9 or 10 11 or 12		
10	0-60 60-90	0-90	9 or 10 11 or 12	over 90	9 or 10 11 or 12		
12	0-60 60-90	0-60	9 or 10 11 or 12	over 60	9 or 10 11 or 12		
15"	0-60 60-90	0-40	9 or 10 11 or 12	40-140	9 or 10 11 or 12	over 140	13 or 14 14 or 15
18	0-60 60-90			0-100	9 or 10 11 or 12	over 100	13 or 14 14 or 15

Bracing For Tees And Wye Branches With Flanged Side-outlets

Size of Side Outlet	Pressure	See Dwg No.	Pressure	See Dwg No.	Pressure	See Dwg No.
9"	0-110	16, 17, or 18	over 110	18, 19 or 20		
10	0-90	16, 17 or 18	over 90	18, 19 or 20		
12"	0-60	16, 17 or 18	over 60	18, 19 or 20		
15"	0-40	16, 17 or 18	40-140	18, 19 or 20	over 140	21 or 22

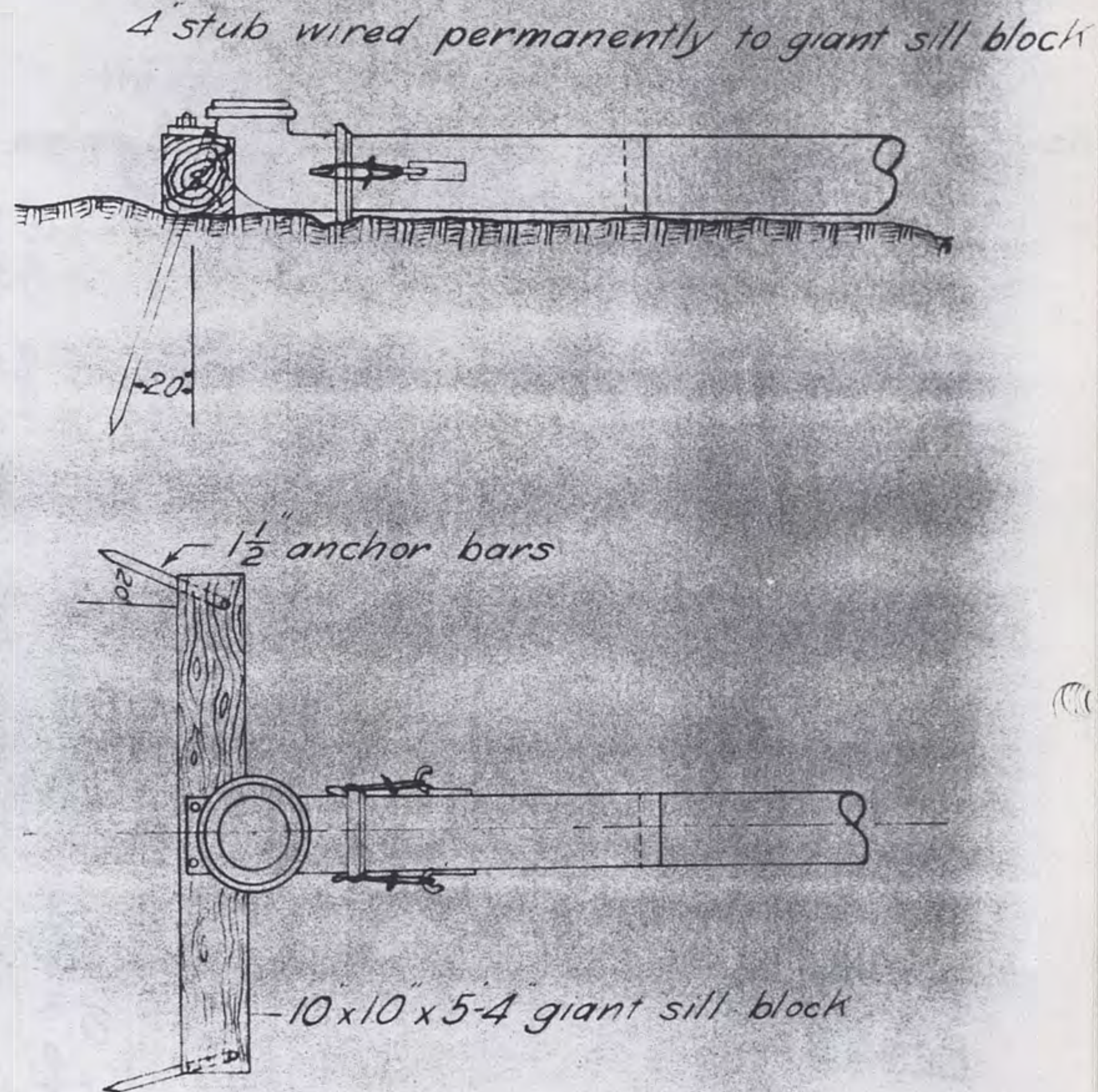
Bracing for Crosses With Flanged Side-outlets

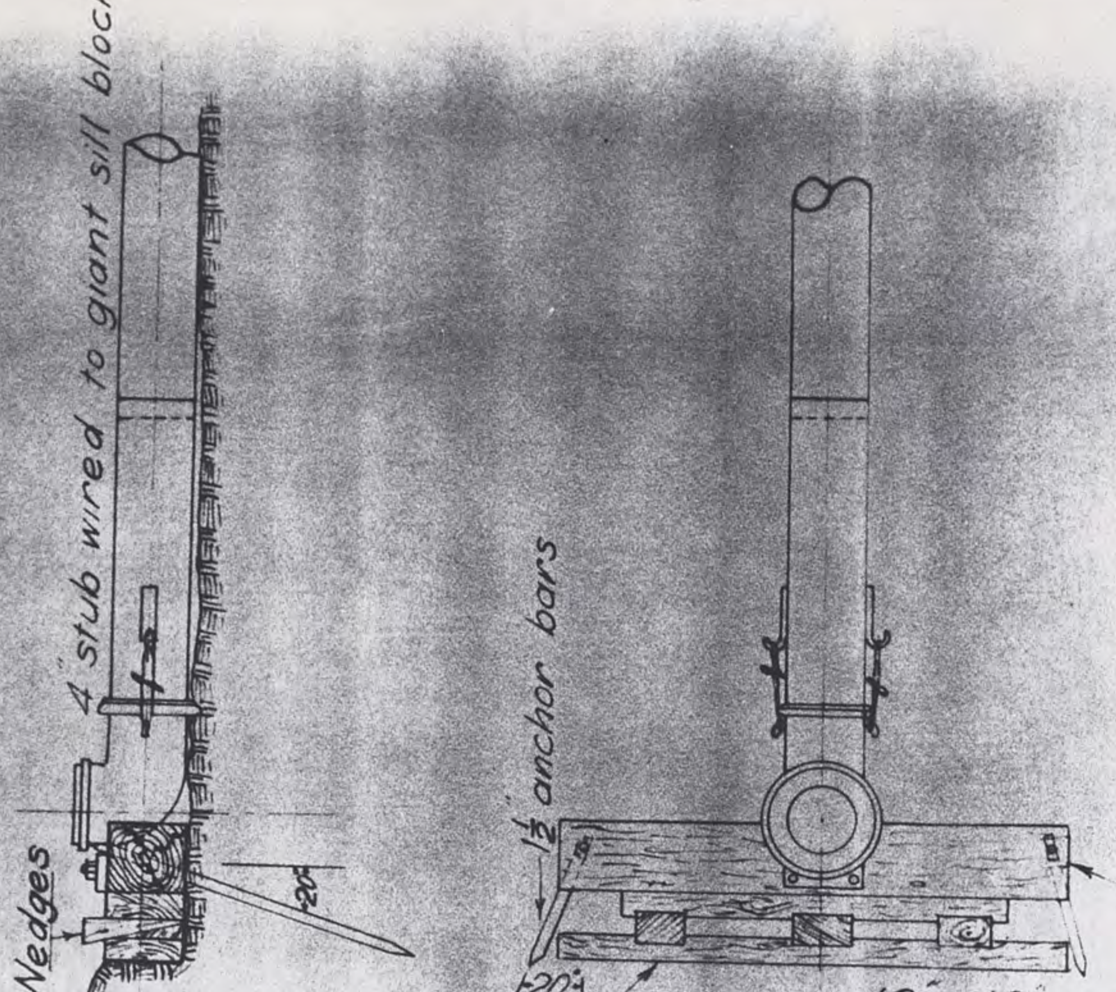
Size of Side Outlet	Pressure	See Dwg No.	Pressure	See Dwg No.	Pressure	See Dwg No.
9	0-110	23	over 110	24 or 25		
10	0-190	23	over 90	24 or 25		
12	0-60	23	over 60	24 or 25		
15	0-40	23	40-140	24 or 25	over 140	26 or 27

Where several drawing numbers are given, use the type bracing most suitable for the conditions, giving the first method preference if conditions permit.

Anchor bar bracing for giants

Scale ¼" = 1'0"



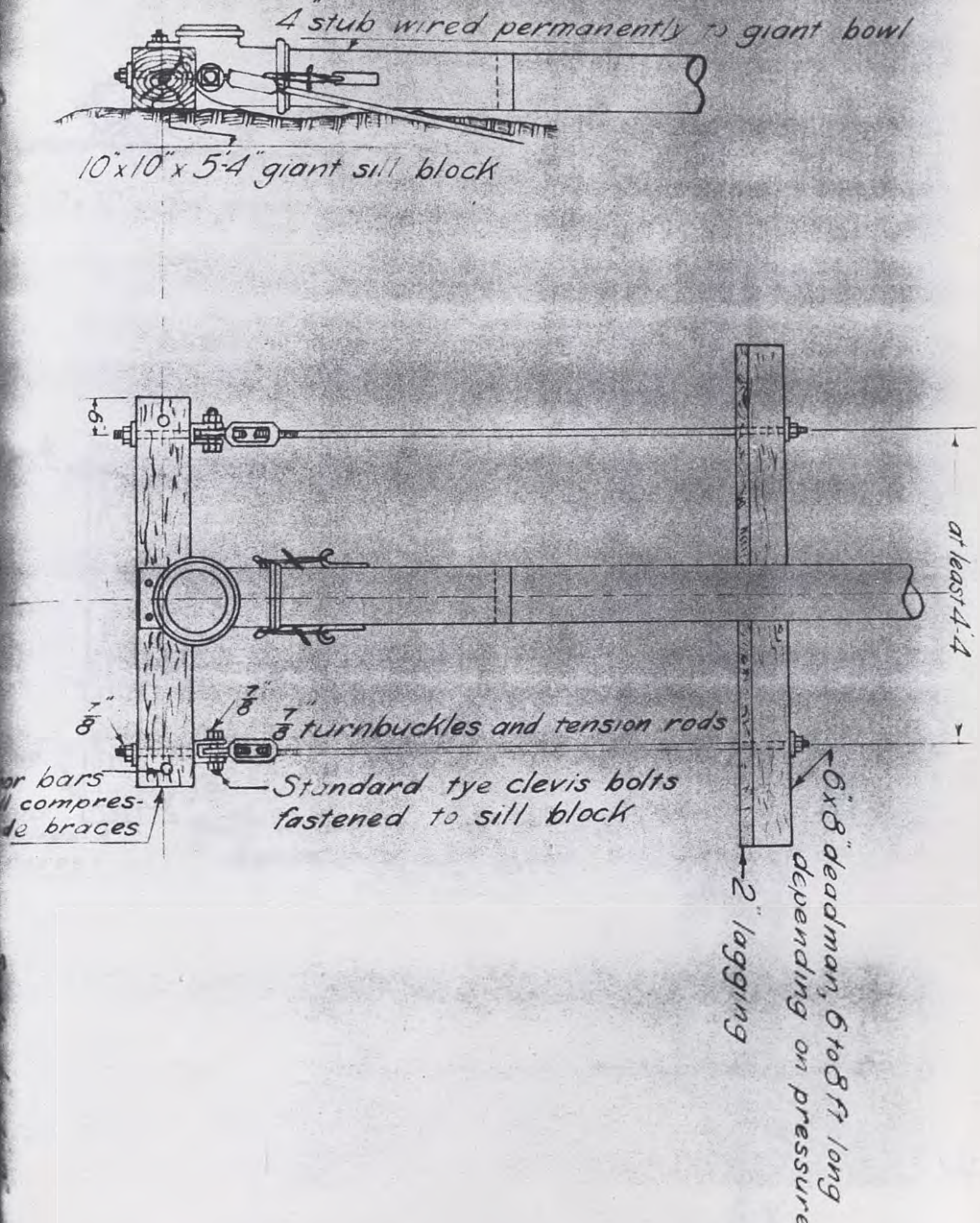


10" x 10" x 54" giant sill block

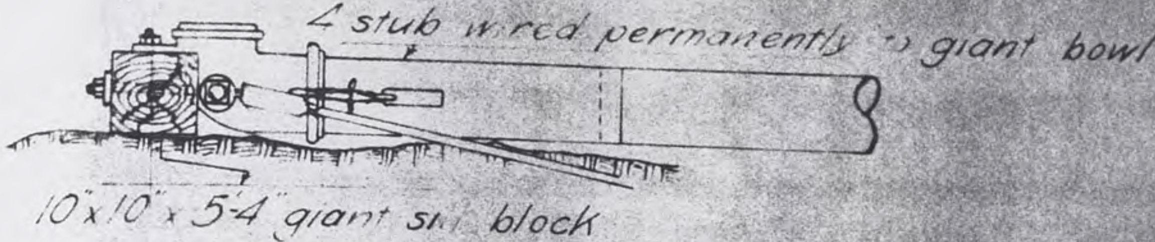
3" plank wedged against shoulder of ground

Pitch pipe slightly downward toward giant, if this can be done without too much digging

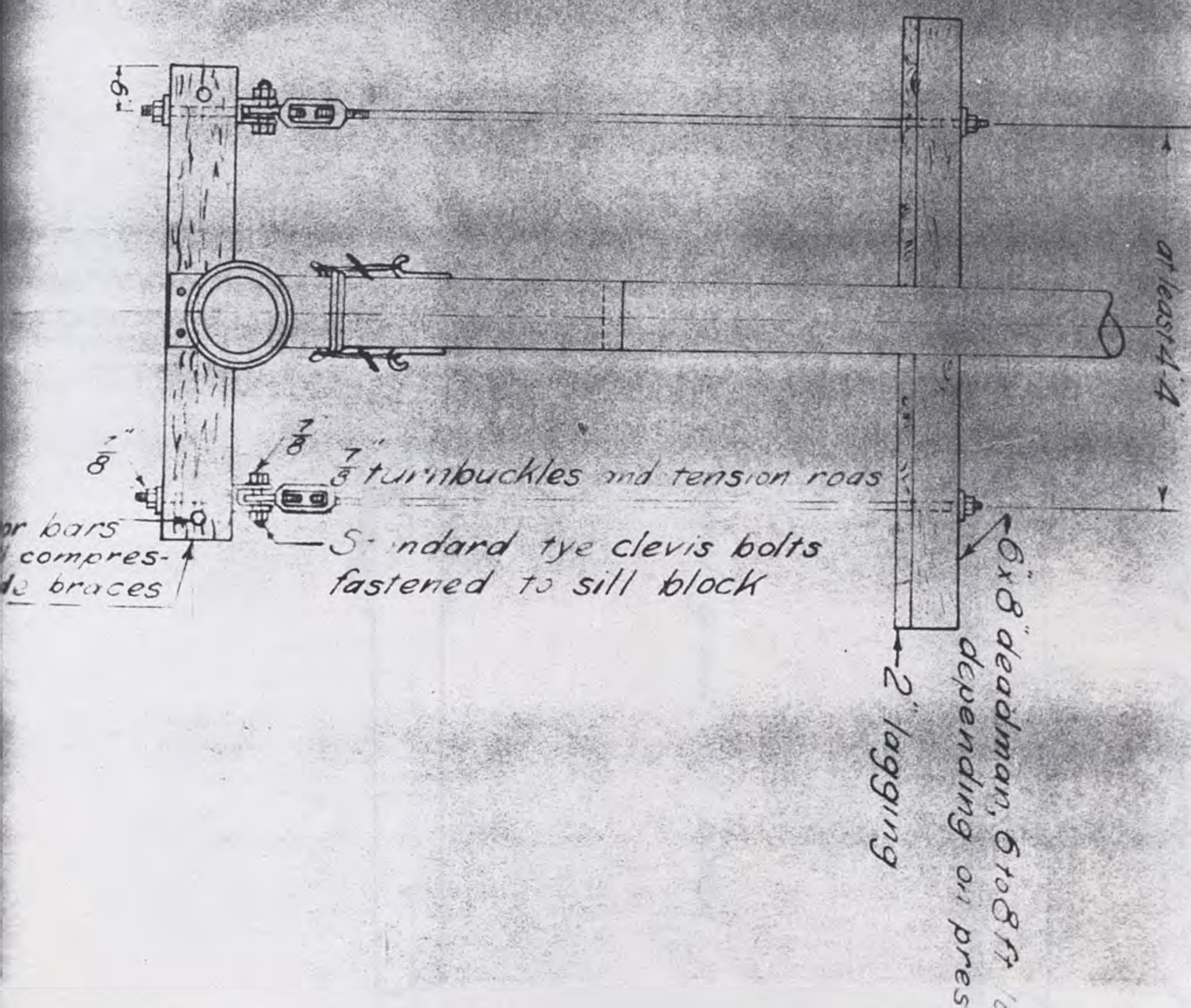
Footboard bracing for giants



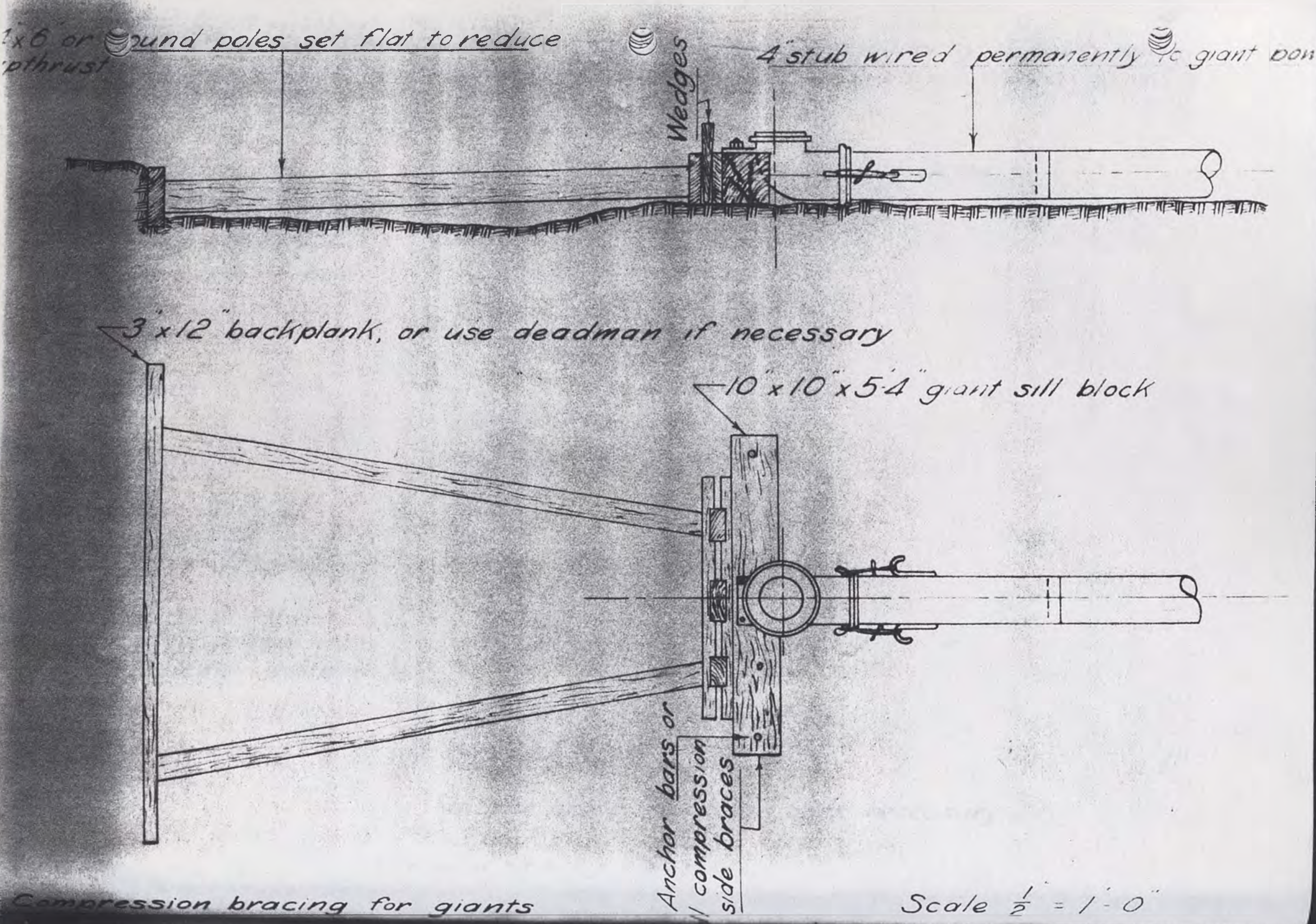
4" stub wired permanently to giant bowl
10"x10" x 5'4" giant sill block
9"
at least 4'4
7/8"
7/8"
7/8" turnbuckles and tension rods
bars
braces
Standard tye clevis bolts
fastened to sill block
6"x8" deadman, 6 to 8 ft long
depending on pressure
2" lagging



4" stub wired permanently to giant bowl
10"x10"x5'4" giant sill block

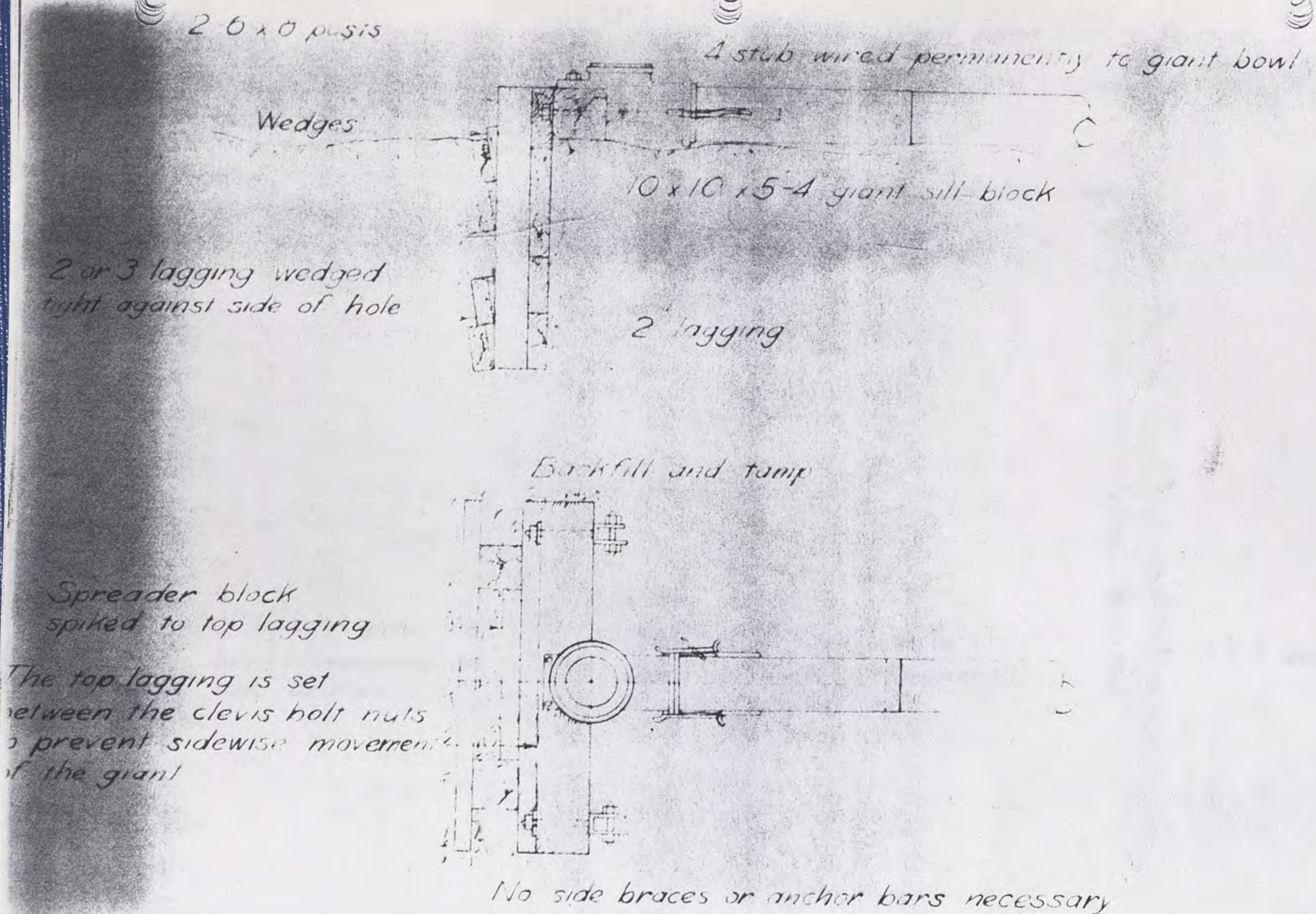


6"
at least 4'4"
7/8"
7/8"
7/8" turnbuckles and tension rods
Standard tye clevis bolts fastened to sill block
or bars
compres-
braces
6"x8" deadman, 6 to 8 ft. long depending on pressure
2" lagging

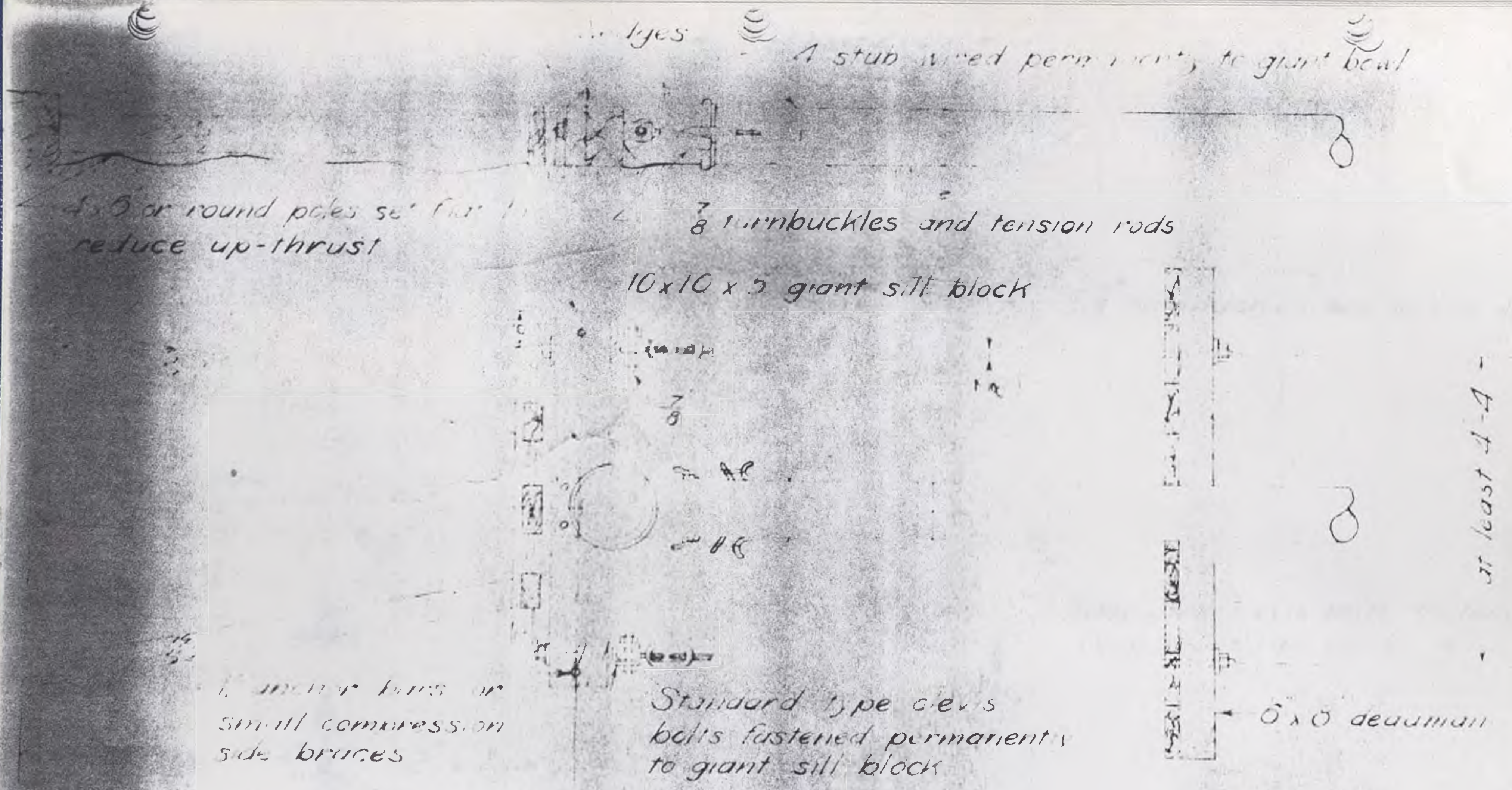


Compression bracing for giants

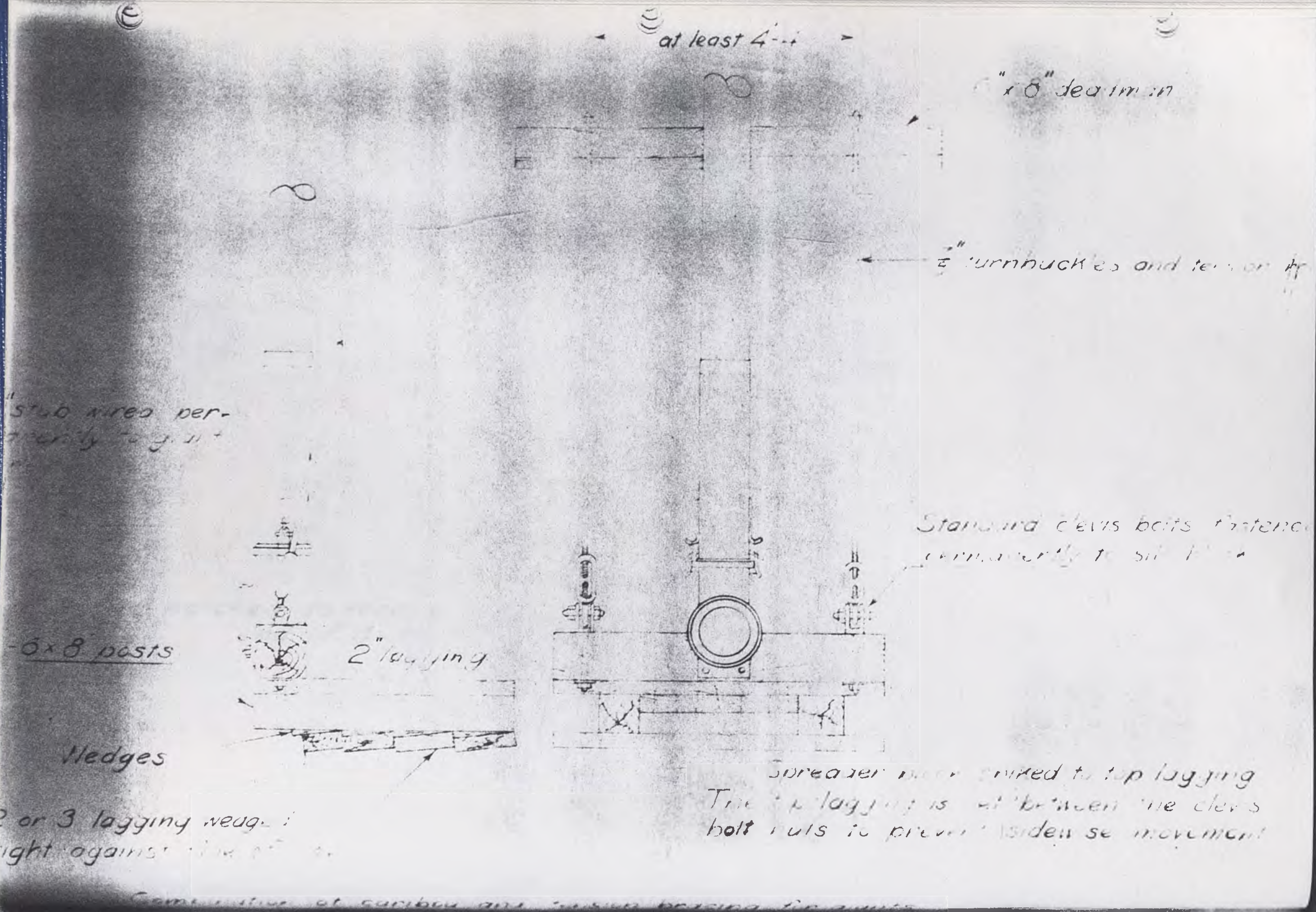
Scale $\frac{1}{2}" = 1'-0"$

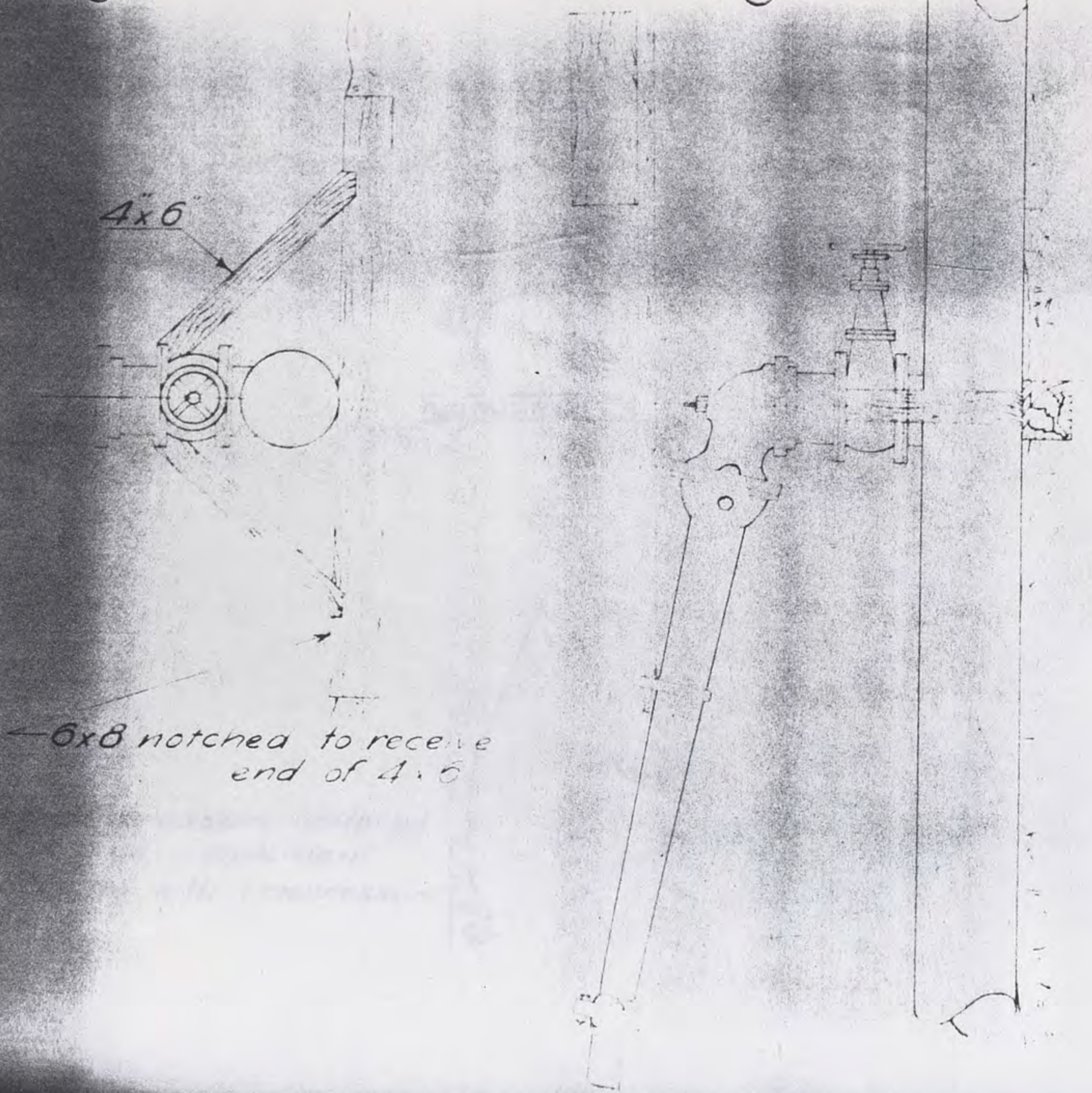


Carbon bracing for giants

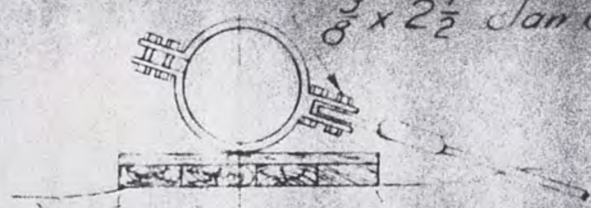


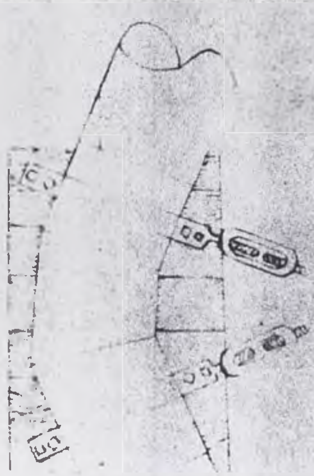
Combination of tension and compression bracing ...


at least 4'
" x 8" deadman
" turnbuckles and
stub wires per-
-6 x 8 posts
2" lagging
Wedges
2 or 3 lagging wedge
tight against
Standard clevis bolts fastened
Spreader spiked to top lagging
bolt nuts to prevent sideways movement

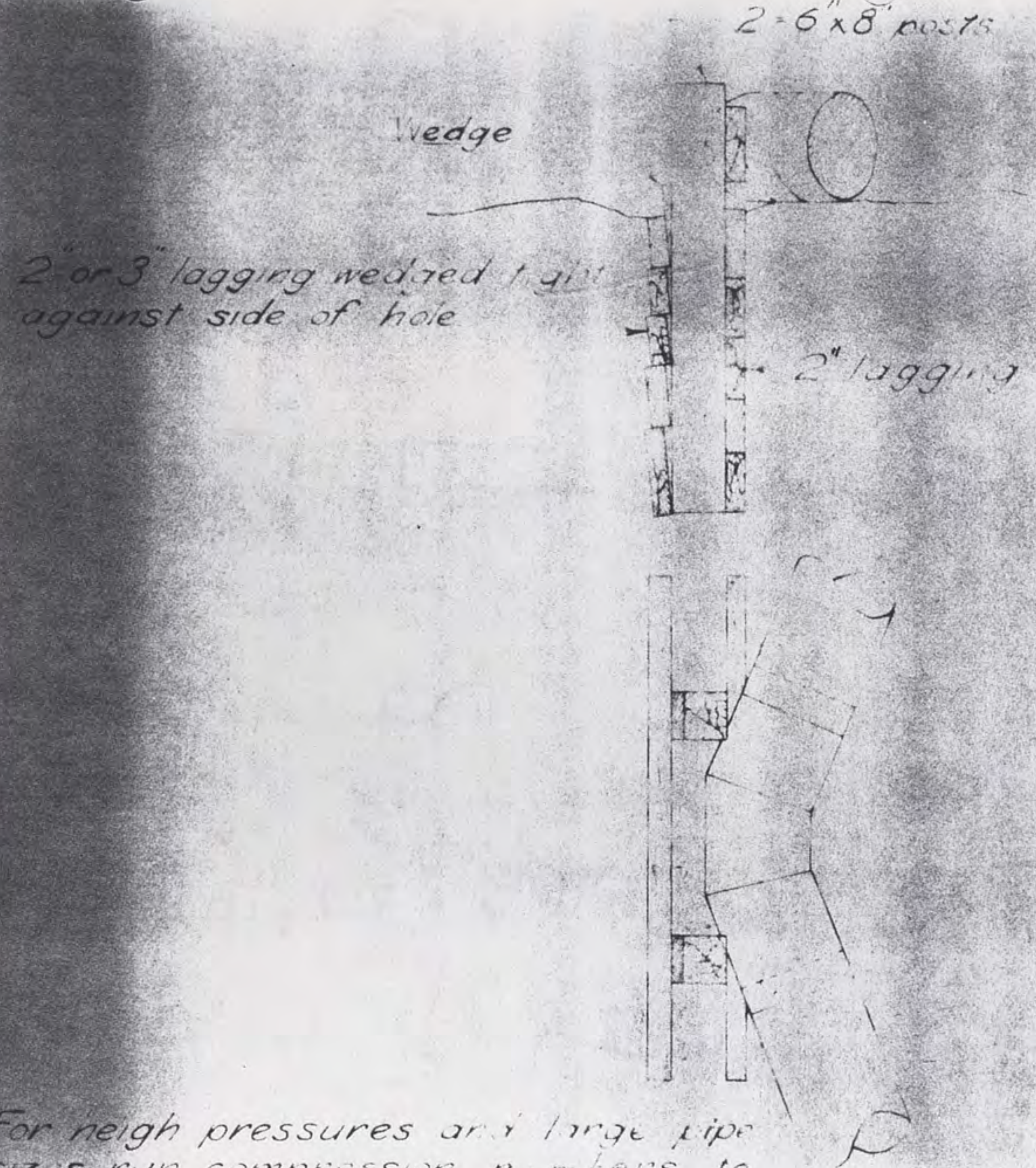

4x6"
6x8 notched to receive
end of 4x6

Size of rods and turnbuckles to depend on size of pipe and pressure



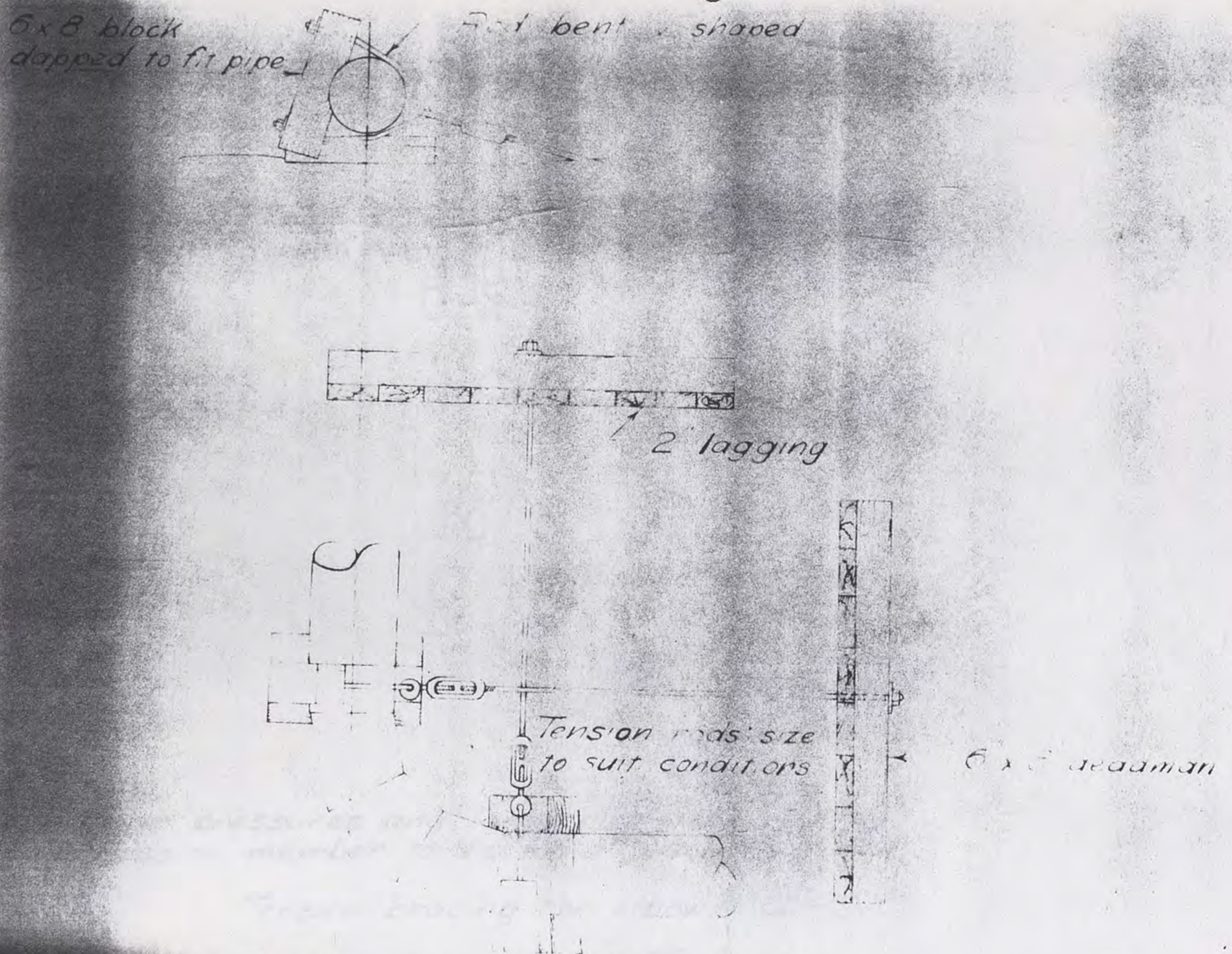


For high pressure or large sizes of pipe, supplement this bracing with compression braces

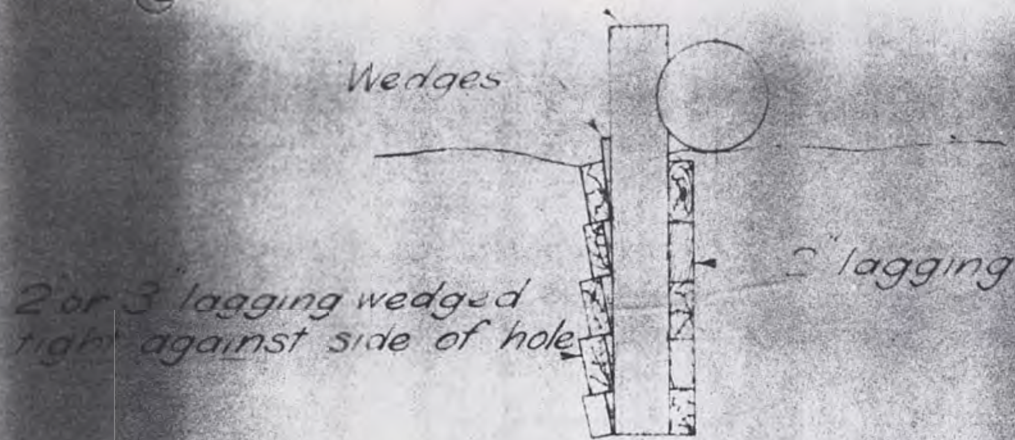


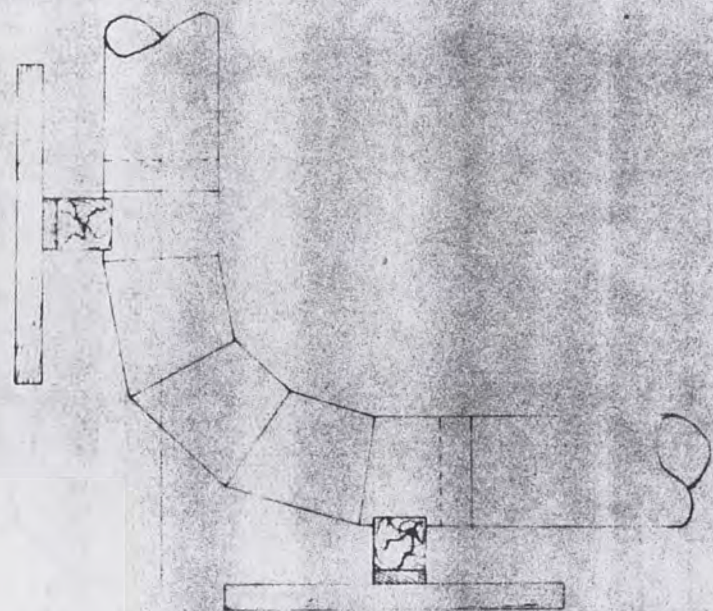
For heigh pressures and large pipe sizes run compression members to tops of 6 x 8 posts

Cariboo bracing for elbows less than 60°



Tension bracing for elbows: 60° - 90°

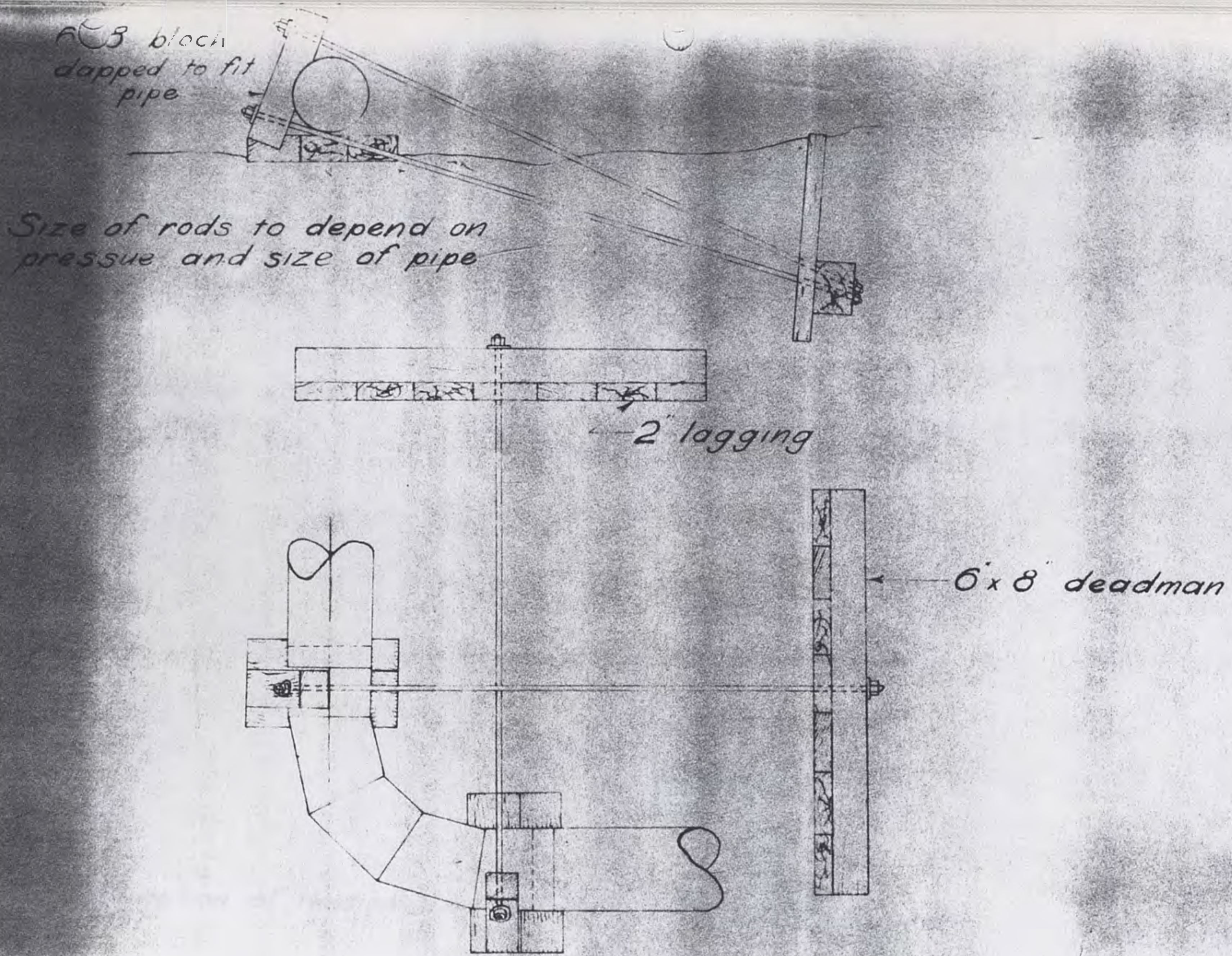




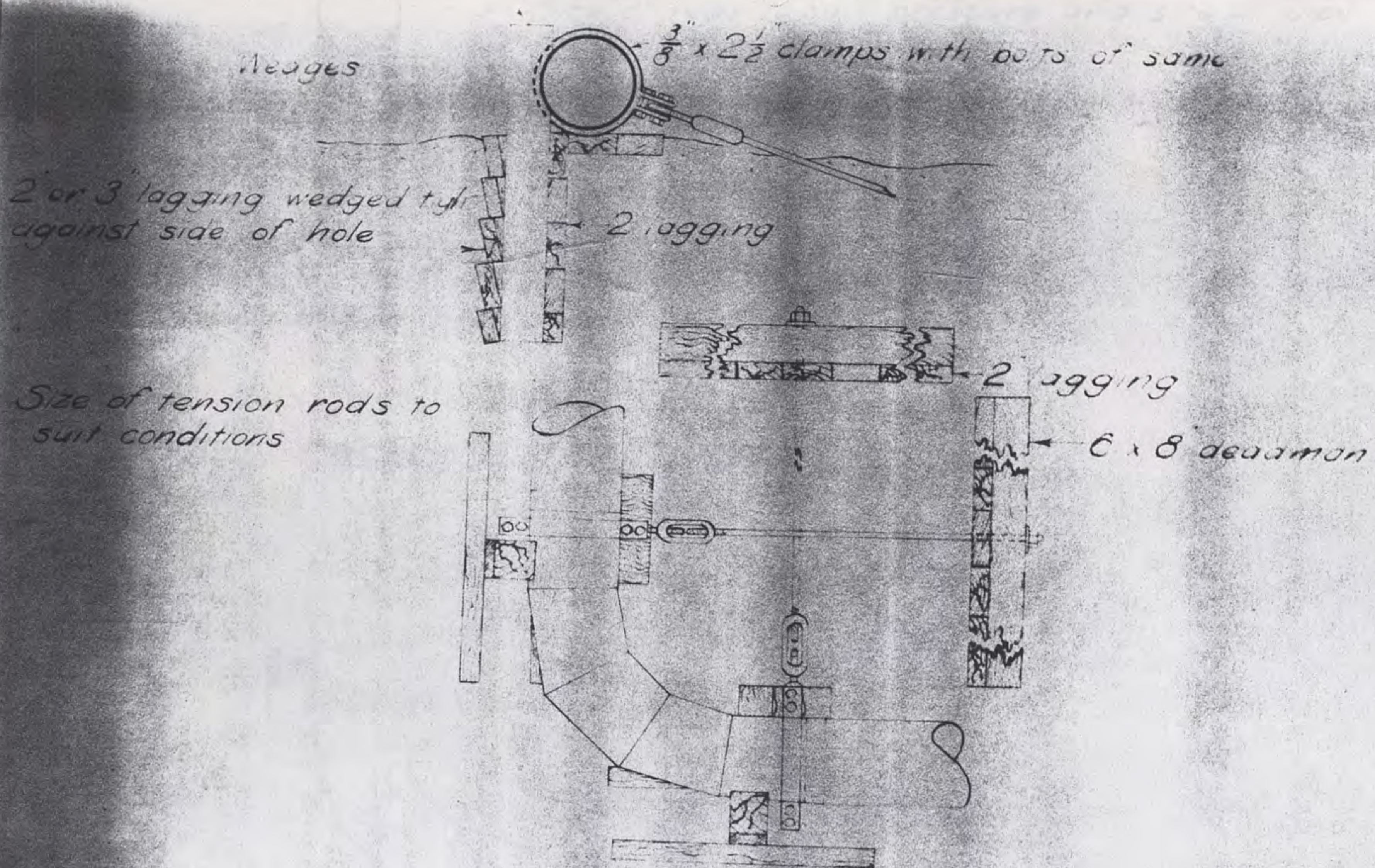
For heigh pressures and large pipe sizes run a compression member to the top of each 6x8 post

Tension bracing for elbows: 60°-90°

Scale 1/2" 1'0"

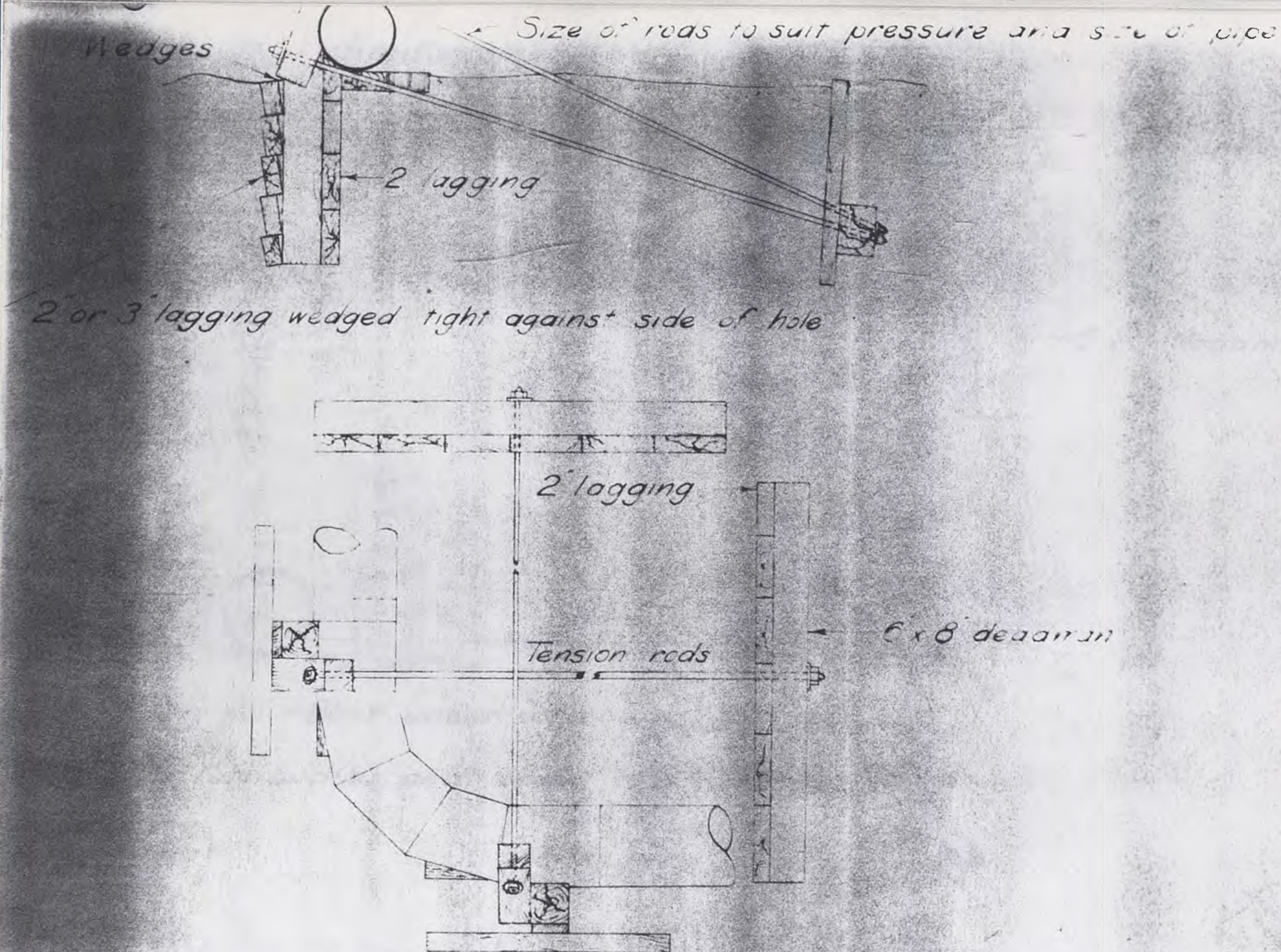


Tension bracing for elbows: 90°



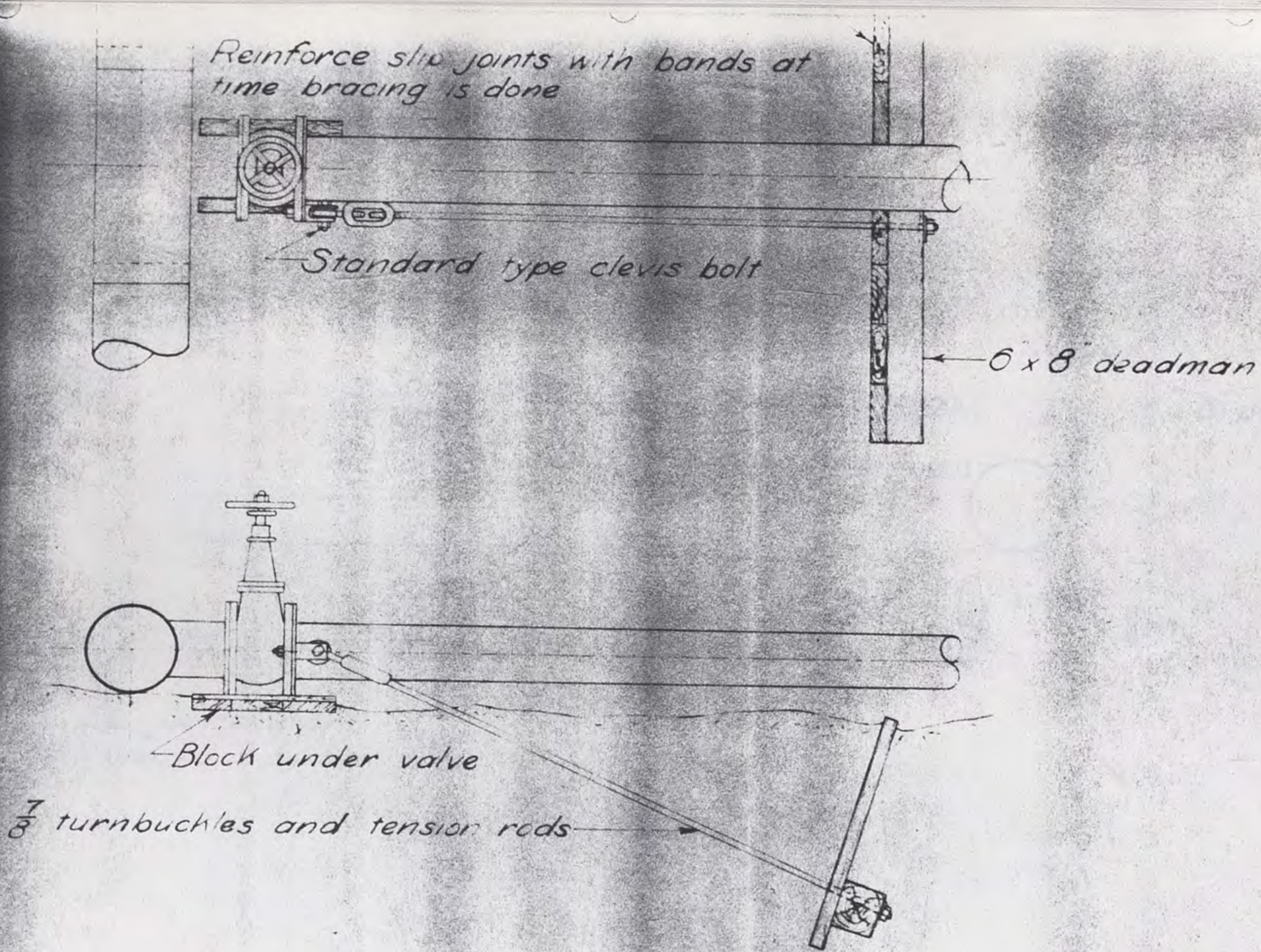
Combination of tension and caribou bracing for elbows

Scale $\frac{1}{2}$" = 1' 0"



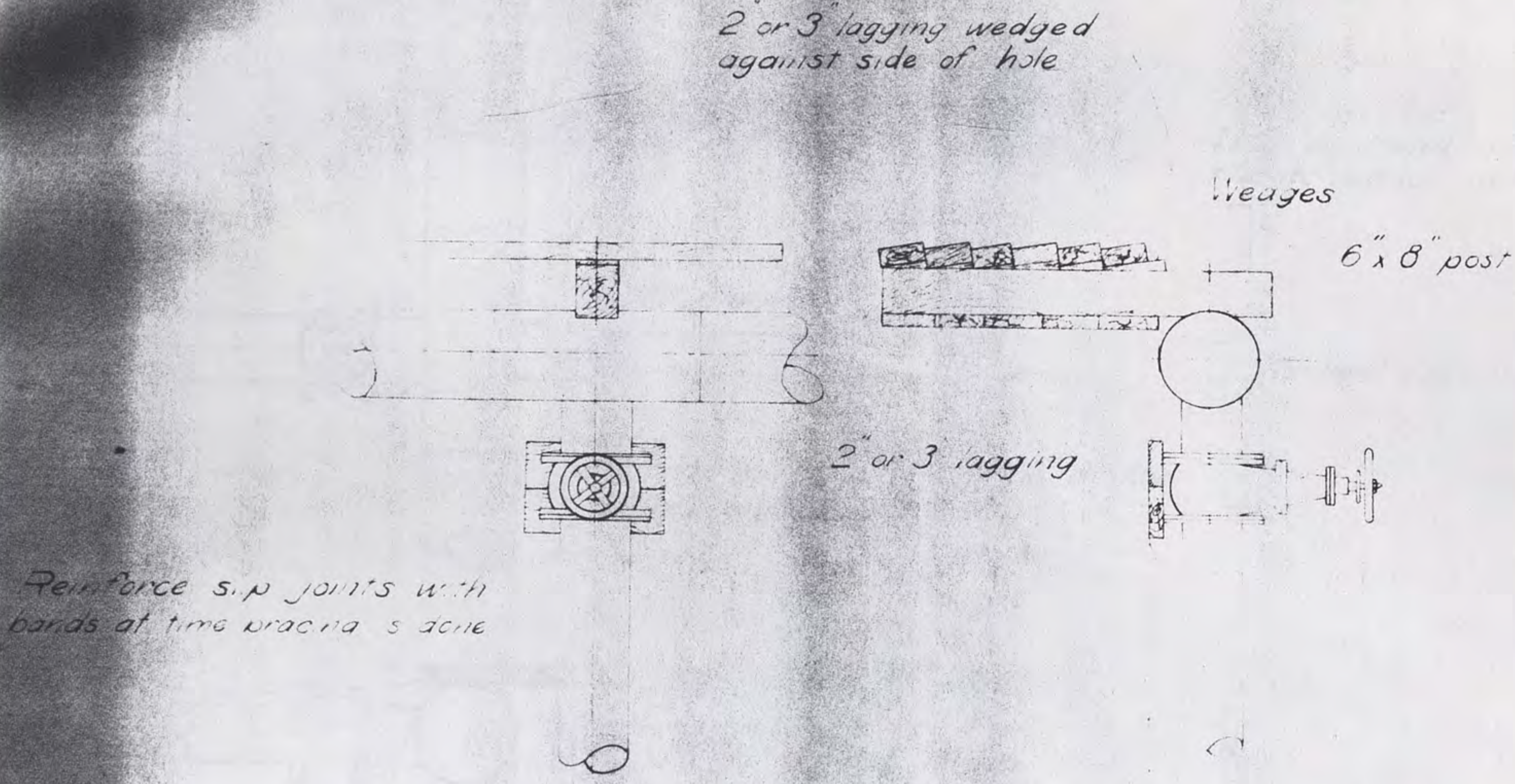
Combination of tension and cribbing bracing for elbows 60° - 90°

Scale

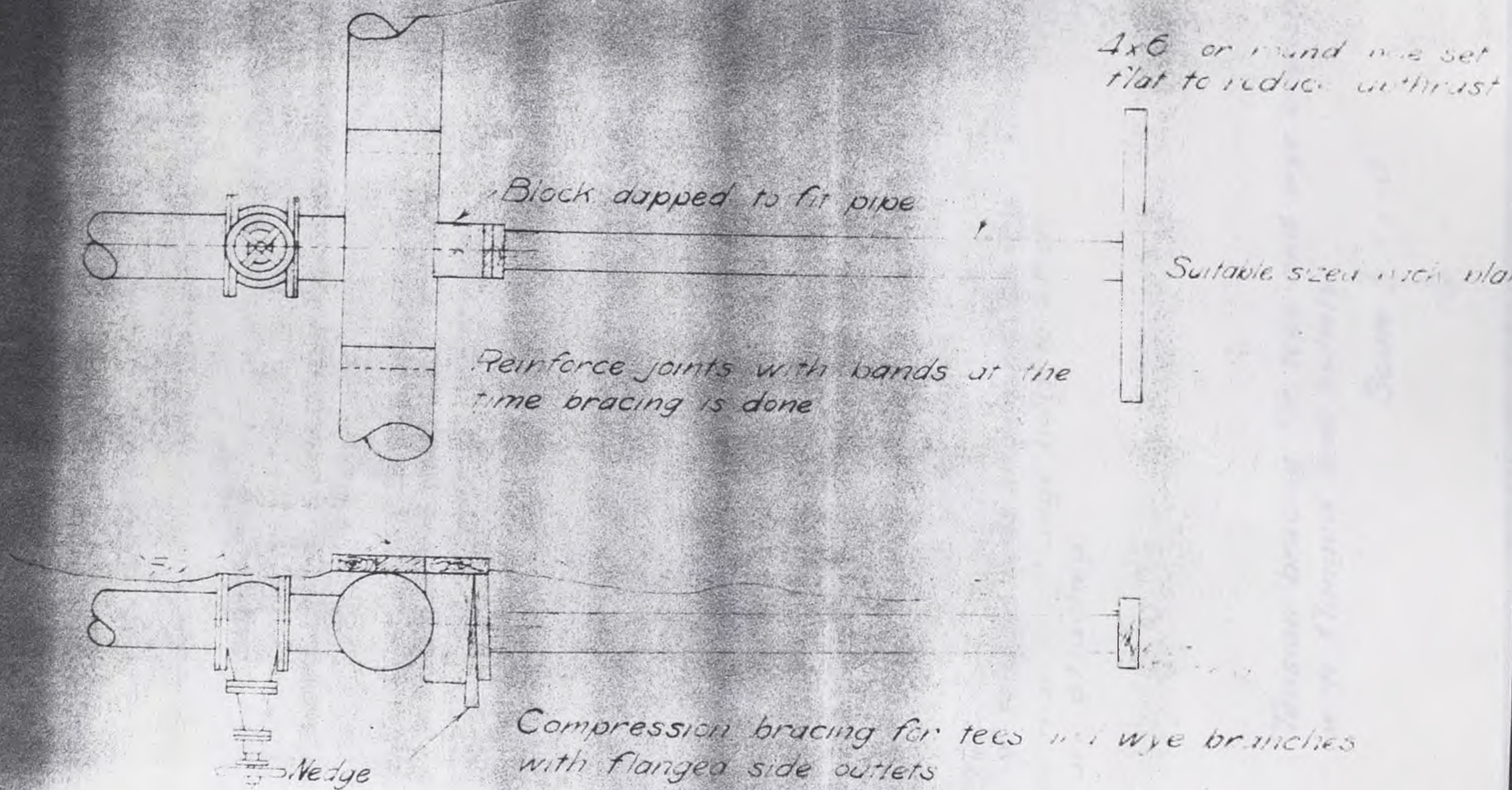


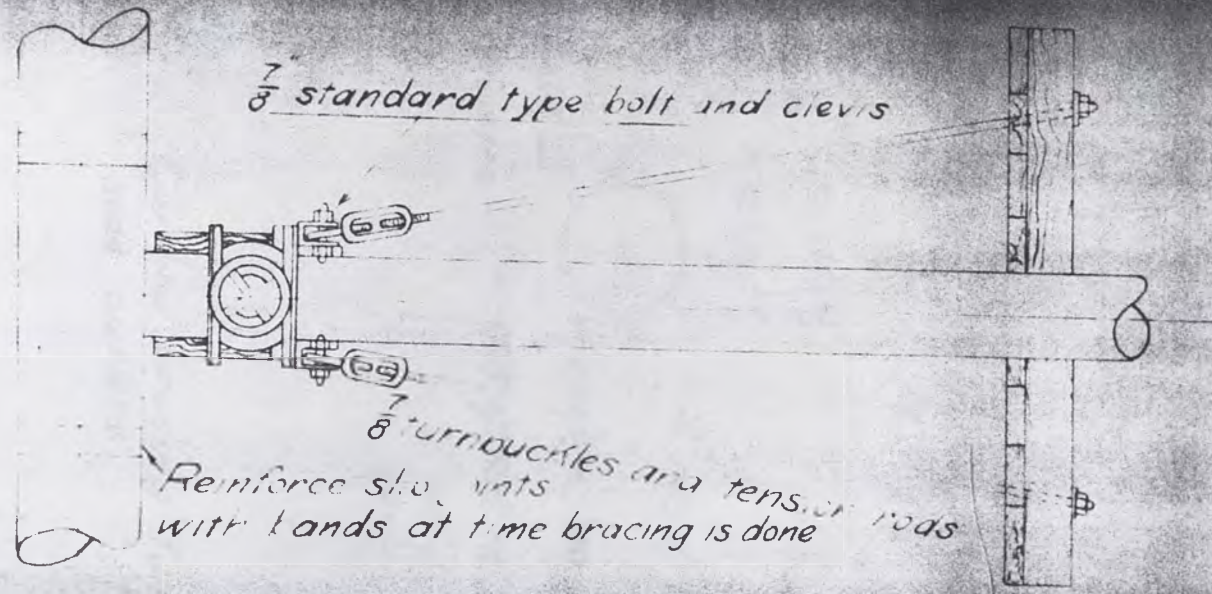
Tension bracing for tees and wye branches with flanged side outlets

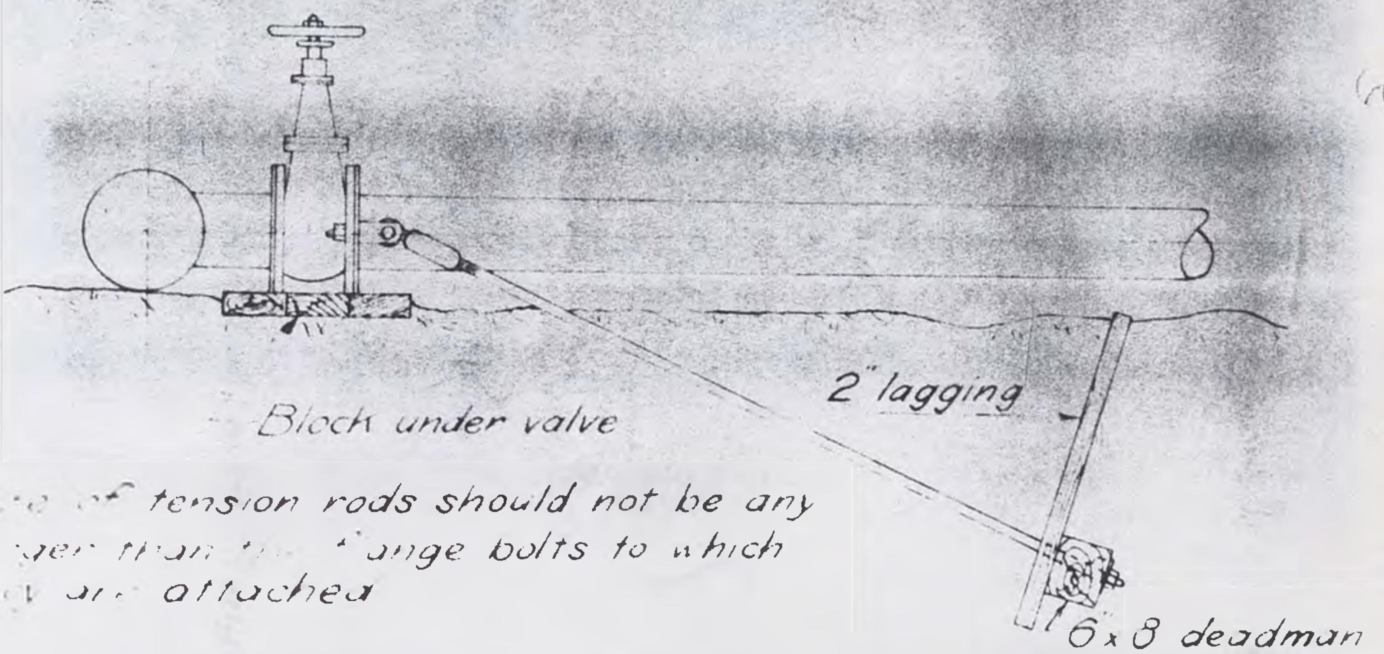
Scale [illegible]



Cariboo bracing for tees and wye branches with flanged


4x6 or round ... set flat to reduce ... thrust
Block dapped to fit pipe
Suitable sized ... pla
Reinforce joints with bands at the time bracing is done
Wedge
Compression bracing for tees ... wye branches with flanged side outlets

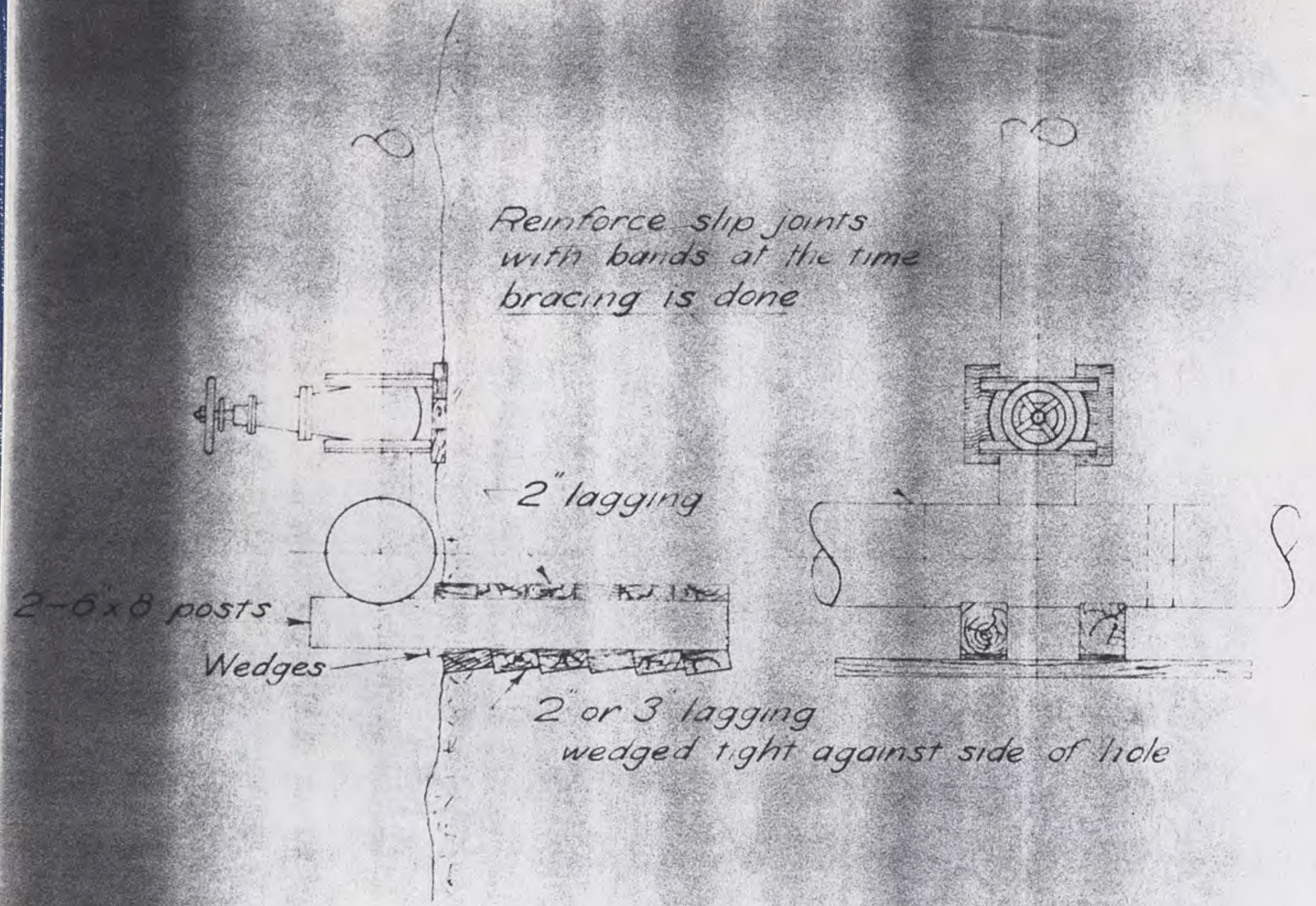




Size of tension rods should not be any larger than the flange bolts to which they are attached

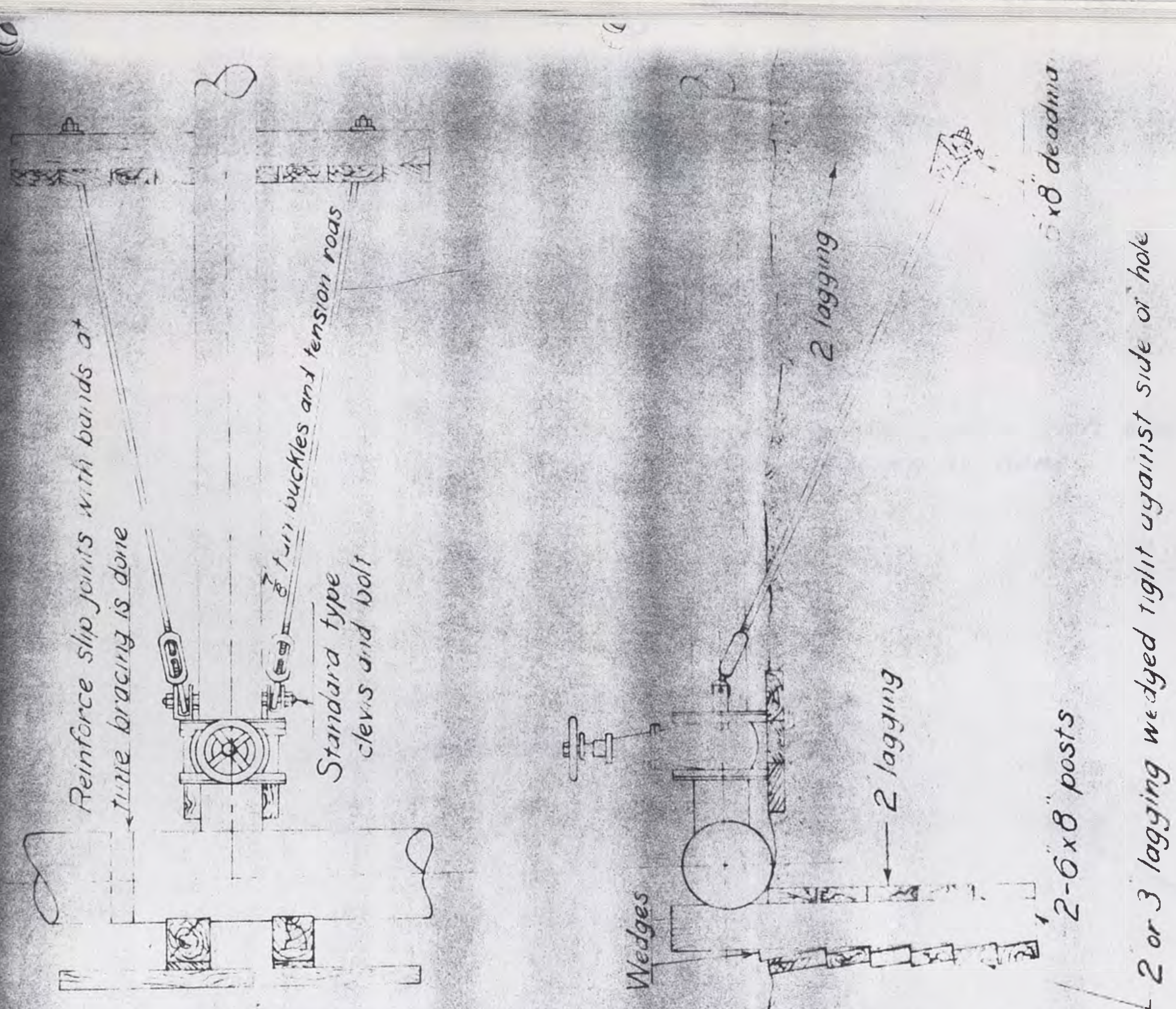
Tension bracing for tees and wye branches with flanged side outlets

Scale $\frac{1}{2}" = 1'-0"$



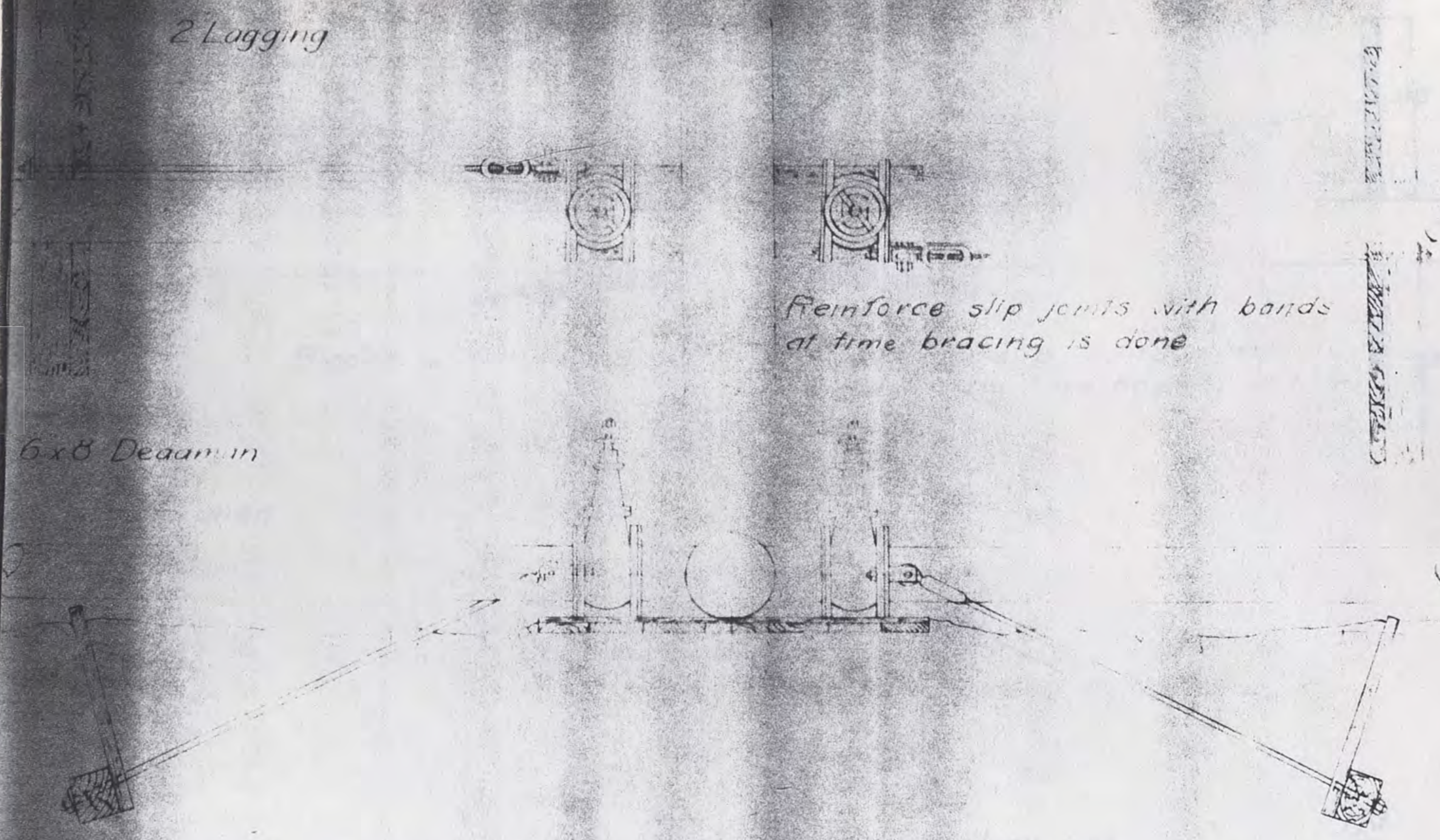
Caribou bracing for tees and wye branches with flanged side outlets

Scale $\frac{1}{2}'' = 1'\text{-}0''$



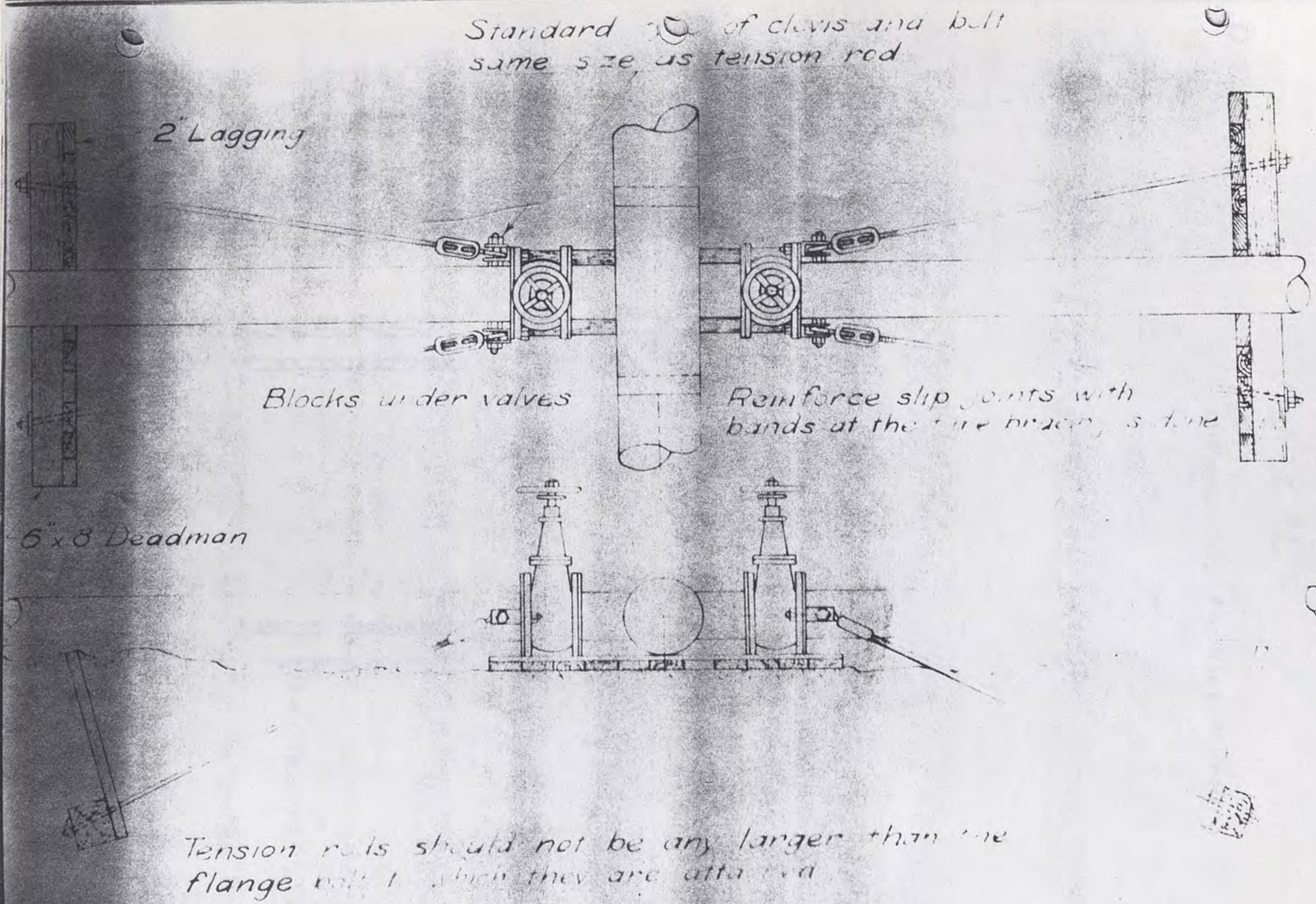
Combination bracing for tees and wye branches with flanged side outlets

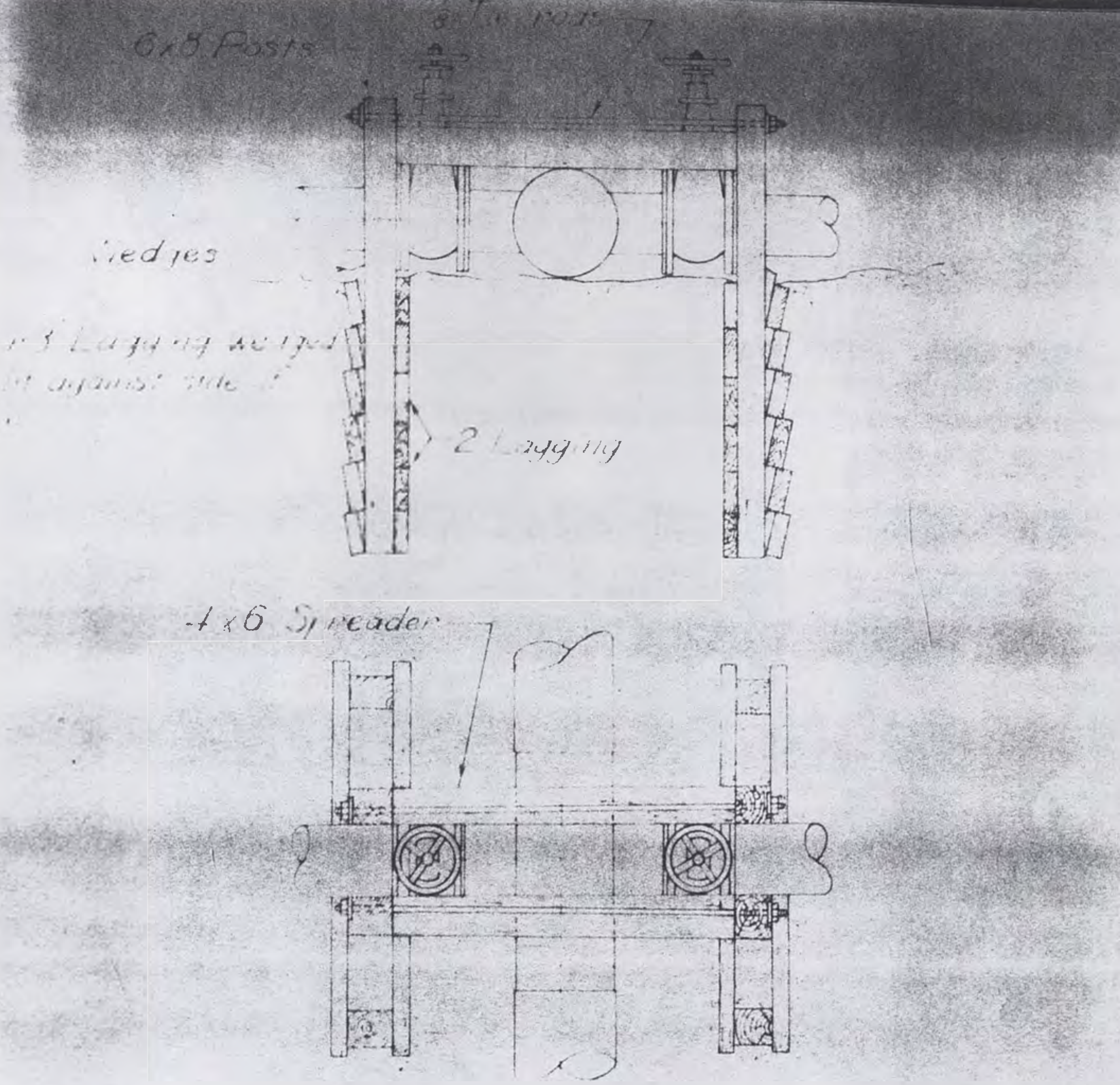
Scale 1/4 = 1-0



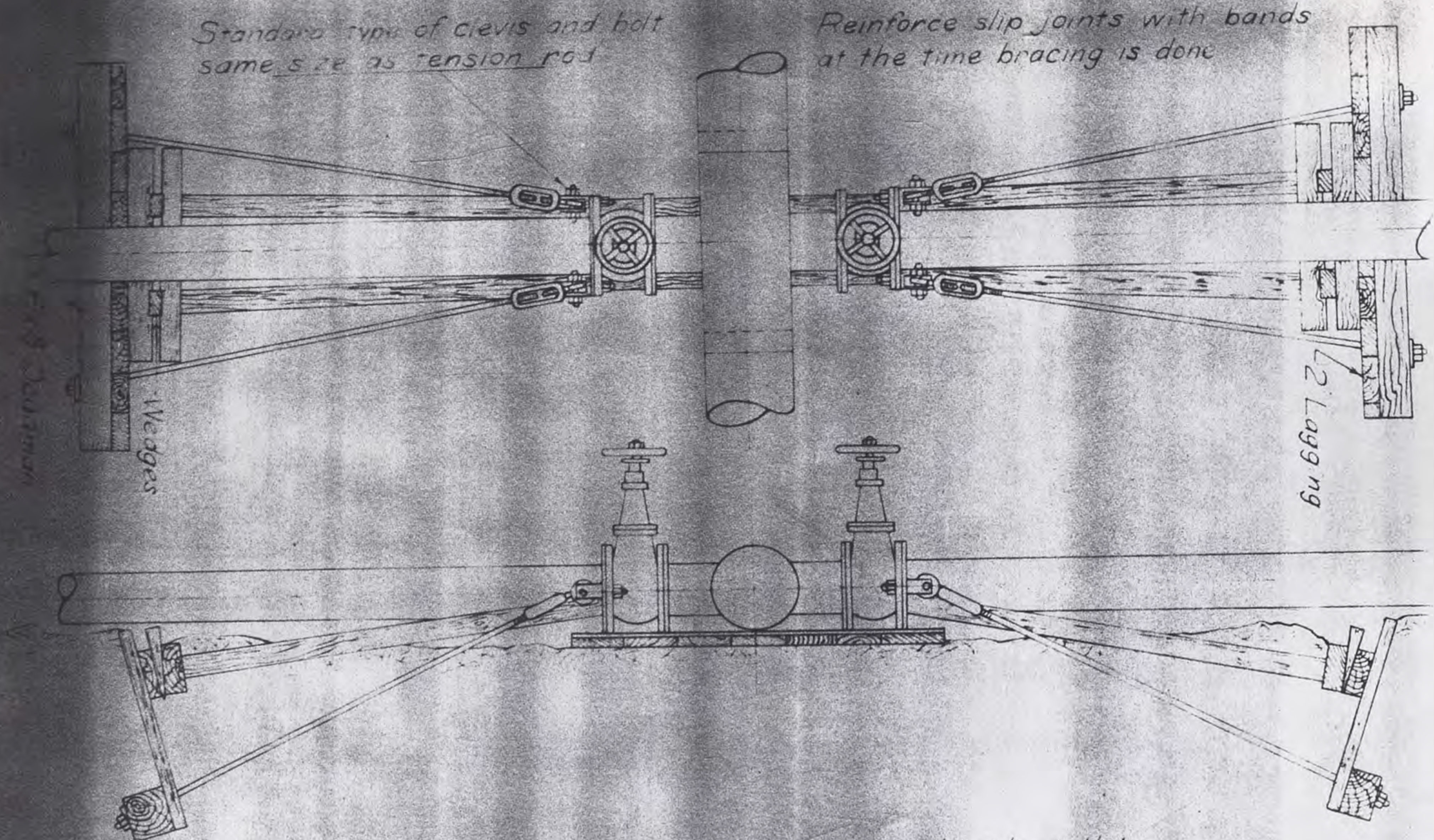
Tension bracing for crosses with flanged outlets

Scale


Standard of clevis and bolt
same size, as tension rod
2" Lagging
Blocks under valves
Reinforce slip joints with
6" x 8 Deadman
Tension rods should not be any larger than the
flange

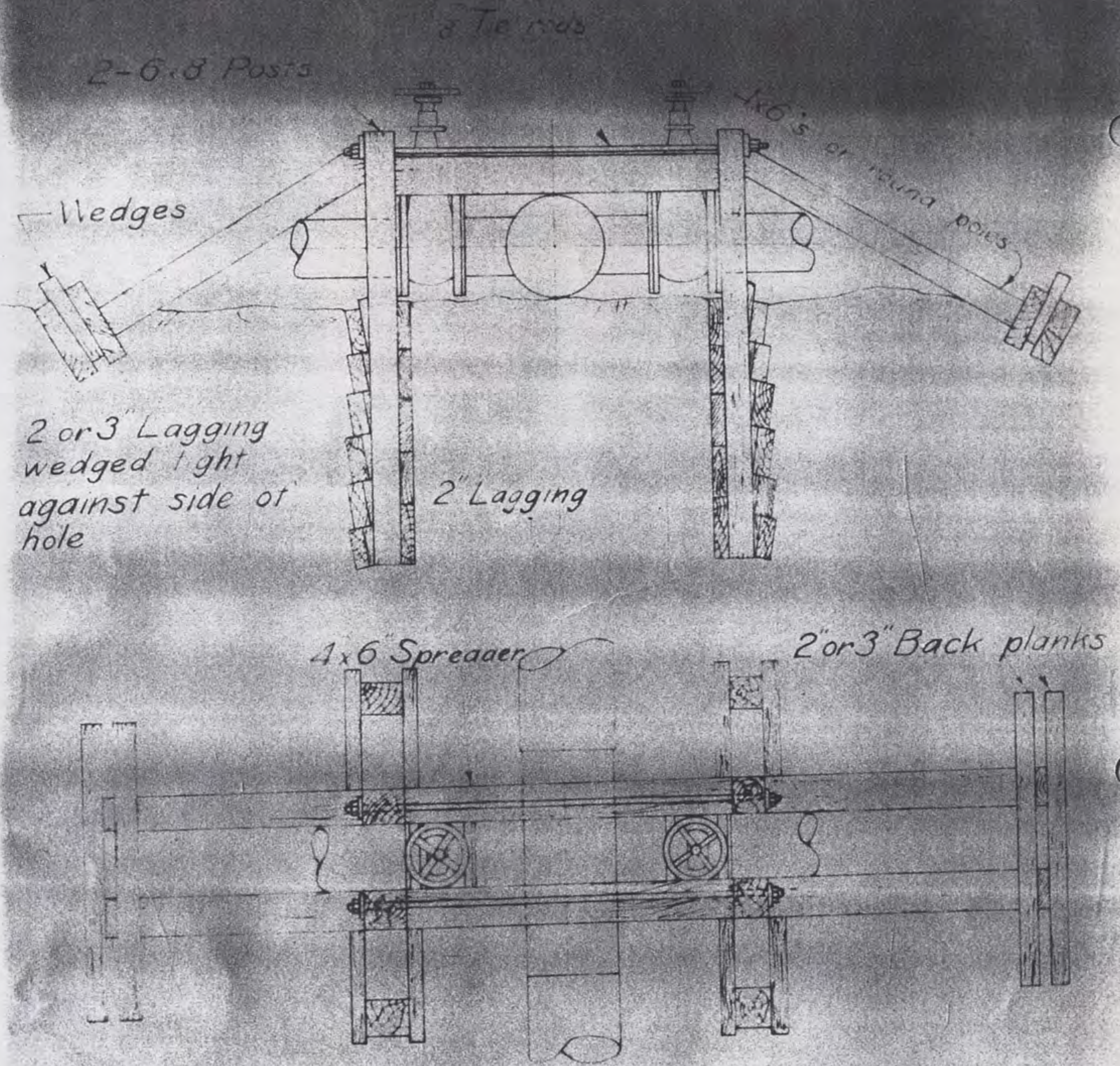


Reinforce slip joints with bands at the time bracing is done



Combination bracing for crosses, with flanged side-outlets

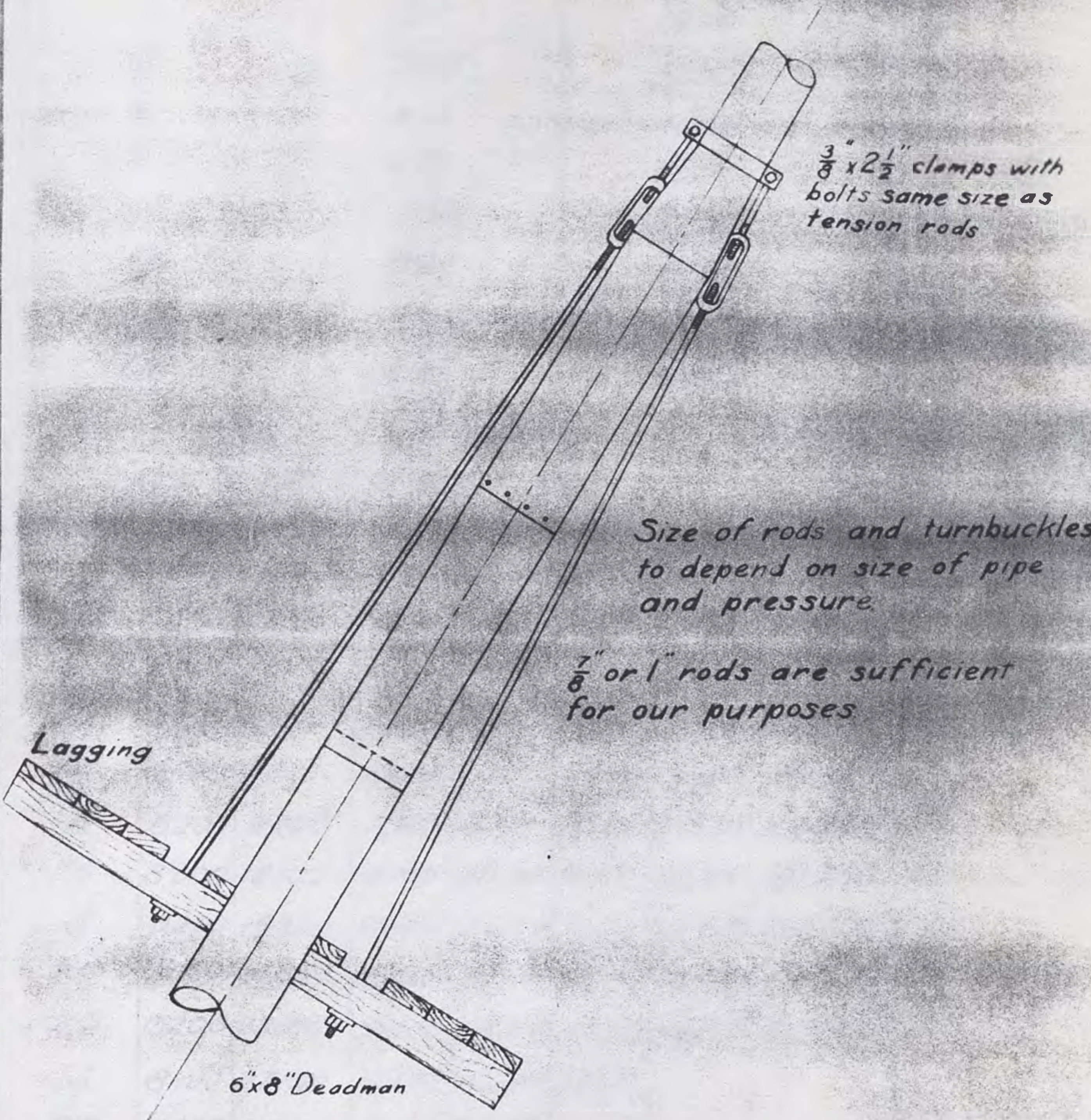
Scale $\frac{1}{2}'' = 1'-0''$



Reinforce slip joints with bands at the time bracing is done

Reinforced caribou bracing for crosses

Scale $\frac{1}{2}'' = 1'\text{-}0''$



Tension Bracing
For Reducers
Scale $\frac{1}{2}'' = 1'\text{-}0''$

Safe Working Strength Of Threaded Rods
based on 15,000 lbs. per sq. in

Nominal diameter of rod	Area at root of thread: sq. in	Tensile strength in lbs.
3/8	.068	1,000
1/2	.126	1,900
5/8	.202	3,000
3/4	.302	4,500
7/8	.420	6,300
1	.550	8,250
1 1/8	.694	10,400
1 1/4	.893	13,400
1 1/2	1.295	19,400

Side-thrust Of Tees
due to static pressure only

$$\text{Thrust} = \pi R^2 \times \text{pressure}$$

Size of side outlet	pressure :- lbs per sq. in						
	40	60	80	100	120	140	160
9	2,500	3,800	5,100	6,400	7,600	8,900	10,200
10	3,100	4,700	6,300	7,900	9,400	11,000	12,600
12	4,500	6,800	9,000	11,300	13,600	15,800	18,100
14	6,200	9,200	12,300	15,400	18,500	21,600	24,600
16	8,000	12,100	16,100	20,100	24,100	28,100	32,200
18	10,200	15,300	20,400	25,400	30,500	35,600	40,700
20	12,600	18,800	25,100	31,400	37,700	44,000	50,300
22	15,200	22,800	30,400	38,000	45,600	53,200	60,800
24	18,100	27,100	36,200	45,200	54,300		
26	21,200	31,900	42,500	53,100			
30	28,300	42,400	56,500				
36	40,700	61,100					

This table can also be used for determining the force tending [illegible]