THE PUMPING STATION OF THE CARLOS FRANCISCO MINE
CASAPALCA, PERU, SOUTH AMERICA

A THESIS

SUBMITTED TO THE FACULTY OF THE COLLEGE OF ENGINEERING
IN CANDIDACY FOR THE DEGREE
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BY

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INTRODUCTION

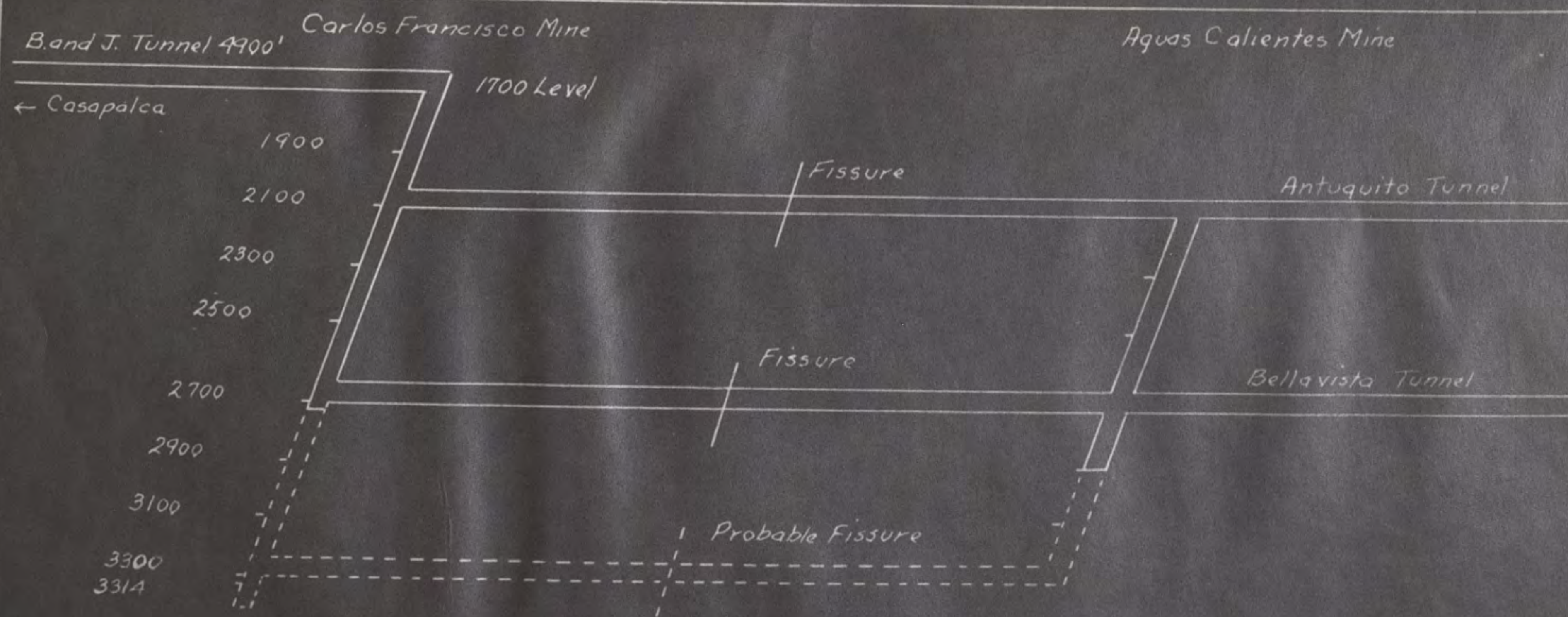
The purpose of this paper is to discuss the pumping station installed on the 3314 level of the Carlos Francisco mine of the Sociedad Minera Backus y Johnston del Peru, located at Casapalca, Peru. However, so much preliminary work had to be done before we could begin the actual installation that it will be necessary to describe, briefly, some of that work to clarify the discussion of the main subject.

The Sociedad Minera Backus y Johnston del Peru, a subsidiary of the Cerro de Pasco Copper Corporation, owns and operates a group of mines in the Casapalca district, of which the most important are the Carlos Francisco and the Aguas Calientes. These two mines, one mile apart, are connected on their 2100 and 2700 levels. They are motor haulage levels, equipped with 3-1/2 ton Baldwin-Westinghouse locomotives operating from a 260 volt D.C. overhead trolley. A 38 cu. ft. hopper bottom type car is used. Each mine has a two and one half compartment, inclined (70 deg.), winze-shaft. The Aguas Calientes shaft, operating between its 2100 and 2900 levels, is used only for men and materials; whereas the Carlos Francisco shaft between the 1700 and 2700 levels of that mine is the main operating shaft for the district. All the ore from the Carlos Francisco and the Aguas Calientes mines is hoisted through the Carlos Francisco shaft. The ore produced in these mines is by-passed to its 2700 level where it is gathered by the electric trains, brought to the Carlos Francisco shaft, and dumped into an ore pocket located in front of the shaft. The ore is hoisted to the 1700 level in two ton self-dumping skips and emptied into a 150 ton loading pocket. From there it is loaded into electric trains and despatched to the concentrator through the Backus and Johnston Tunnel, which is the main entry from Casapalca to all the mines in the Backus and Johnston group.

In 1934 the following development program was outlined for the Carlos Francisco and the Aguas Calientes mines: (1) to deepen the Carlos Francisco shaft from the 2700 to the 3400 level, (2) to deepen the Aguas Calientes shaft from the 2900 to the 3300 level, and (3) to connect the two shafts on the 3300level with a motor haulage crosscut. Each mine was to be developed, also, on intermediate levels (2900 and 3100). The three levels were to be spaced 54 meters floor to floor measuring from the 2700 level along the incline of the shaft.

The Carlos Francisco mine, together with the section between it and the Aguas Calientes mine produce 10,000 gallons of water per minute. A fault to the morth of the Carlos Francisco shaft produces 10% of this water and the rest comes from large fissures found approximately midway between the two shafts. Most of the water is tepid, although some of the fissures produce water having a temperature between 115 and 120 deg.F.

In 1934 this water was being carried to the surface on the 2700 level a distance of 15,000 ft. in a drainage ditch dug to one side of the track. Previous to 1927 this water was carried 9000 ft. to the surface in a similar manner on the 2100 level. The 2100 level was driven as the Antuquito



Section through C.F.^{co} and A.C. shafts in 1934, showing proposed development work - - -

Distances

C.F.^{co} Shaft to A.C. Shaft	5,400'
" " " " Casapalca via B. and J. Tunnel	4,900'
" " " " Surface (2100) " A.C. and Antuquito Tunnel	9,000'
" " " " " (2700) " " " Bellavista "	15,000'
" " " " " (3300) estimated	32,000'

Not Drawn to Scale R.A.M.

Plate A

Tunnel and the 2700 level as the Bellavista Tunnel, but now, these names are only used when referring to the section of the tunnel from the Aguas Calientes shaft to the surface. Driving these two tunnels has definitely proven the existence of this water, where to look for it, and how much of it to expect. Also, when the fissures are cut the flow of water will be about 15,000 gallons per minute, which will decrease gradually to a constant flow of 10,000 gallons per minute. When the Bellavista Tunnel cut the fissure on the 2700 level water ceased to flow from the fissures on the 2100 level. Therefore, it was assumed that the water would drain in a similar manner when the fissures were cut on the 3300 level. The idea of draining this water by driving a drainage tunnel to the surface was considered, but turned down due to the time necessary to make such a drive. It would have required driving 32,000 ft. at an estimated cost of $2,500,000. Although the corporation had just driven the 32,000 ft. Kingsmill Tunnel (formerly known as the Mahr Tunnel) to drain the Morococha district, the Morococha mines had been able to carry out normal development and mining operations as they had a large pumping station already installed. Casapalca was not so fortunate. The time element was an important factor to Casapalca so it was decided to install a pumping station on the 3314 level of the Carlos Francisco mine. It offered the advantage of a cheaper first cost, and could be installed in a reasonable time. With the pumps installed we could develop the Carlos Francisco mine while making the drive to Aguas Calientes. This procedure would offer at least two years saving in time. Also, the pumping plant at Morococha was being dismantled and was available for use at Casapalca.

The development program required five and one half years to finish, and all the work was carried out under my personal supervision. For the first two and one half years as the Development Foreman and the last three years as the General Mine Foreman I took part in all the discussions and final recommendations pertaining to this work.

SHAFT SINKING

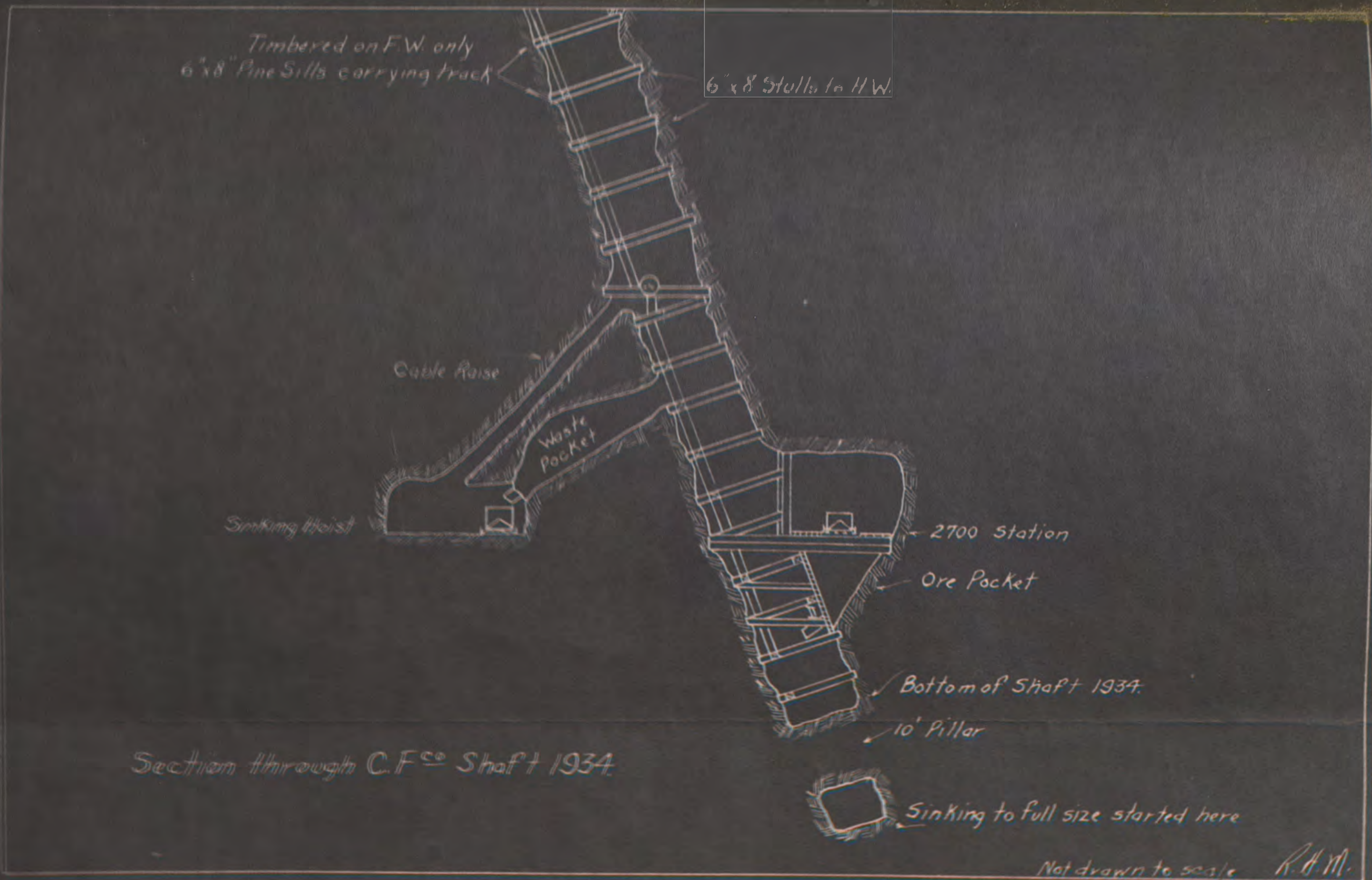
The Carlos Francisco shaft measures 7 ft. by 19 ft., and is timbered on the footwall side only, with 6 in. by 8 in. pine sills for carrying the 30# rail for the skip track. The andesite through which the shaft passes, requires no support on the hanging wall excepting where the stations have been cut. From the footwall sills to the hanging wall side of the shaft are four 6 in. by 8 in. pine stulls,having one end framed to fit a mortise cut in the pine sill, and the other end square cut to rest in a deep hitch cut in the hanging wall rock. Two of the stulls are placed at the ends of the sills in the same position as the end plates in a full shaft set, and the other two serve as dividers for the shaft divisions. In the manway compartment a 6 in. permanent air line and a 2 in. water line are carried.

The new part of the shaft was to follow the general plan of the older section, and the work was to be done on a three shift basis using 4 machinemen, 4 machine helpers, 2 timbermen, 2 timber helpers, 4 muckers, and 1 electrician per shift. Since there were no men in the district having previous shaft experience, the crews were made up of men from all sections of the mine. We tried, of course, to choose men who would be suitable for shaft work, selecting those of proven ability. All the shaftmen chosen were Peruvian Indians. The three Peruvian mine bosses who were picked for our shift bosses were selected in the same manner.

Before commencing actual sinking, a small construction hoist was installed on the 2700 level to handle the waste from sinking through the manway compartment of the Carlos Francisco shaft. Also, a small waste pocket of 30 tons capacity was cut out into which the one ton self-dumping skip could discharge. The electric trains loaded the waste from this pocket and hauled it to the Aguas Calientes mine where it was used as back-fill in the stopes. From the hoist room to the manway compartment a small raise was driven for the 3/4 in. hoisting cable. A sheave wheel and the turnout for the skip were installed to finish the preliminary work.

In 1934 the bottom of the Carlos Francisco shaft was 30 ft. below the 2700 level, which allowed the main skips 3 ft. clearance when in position to load from the 2700 ore pocket. Since all the ore from this section is hoisted in the Carlos Francisco shaft, our work had to be planned so as not to interfere with this operation. For this reason we did not commence actual sinking from the bottom of the old shaft. Instead, we sunk first for a distance of 10ft. in the manway compartment, or south side of the shaft. From the bottom of this pilot shaft, we cut across to the morth side of the shaft at full size, leaving a 10 ft. pillar between the bottom of the old shaft and the new shaft work. With this pillar in place, we could sink to full size without damaging the ore pocket with fly rock from the blasts. All the preliminary work was done with no delay to the regular mine operations. (See Plate #1 which shows the preliminary work done.)

Actual sinking to full size commenced from the bottom of



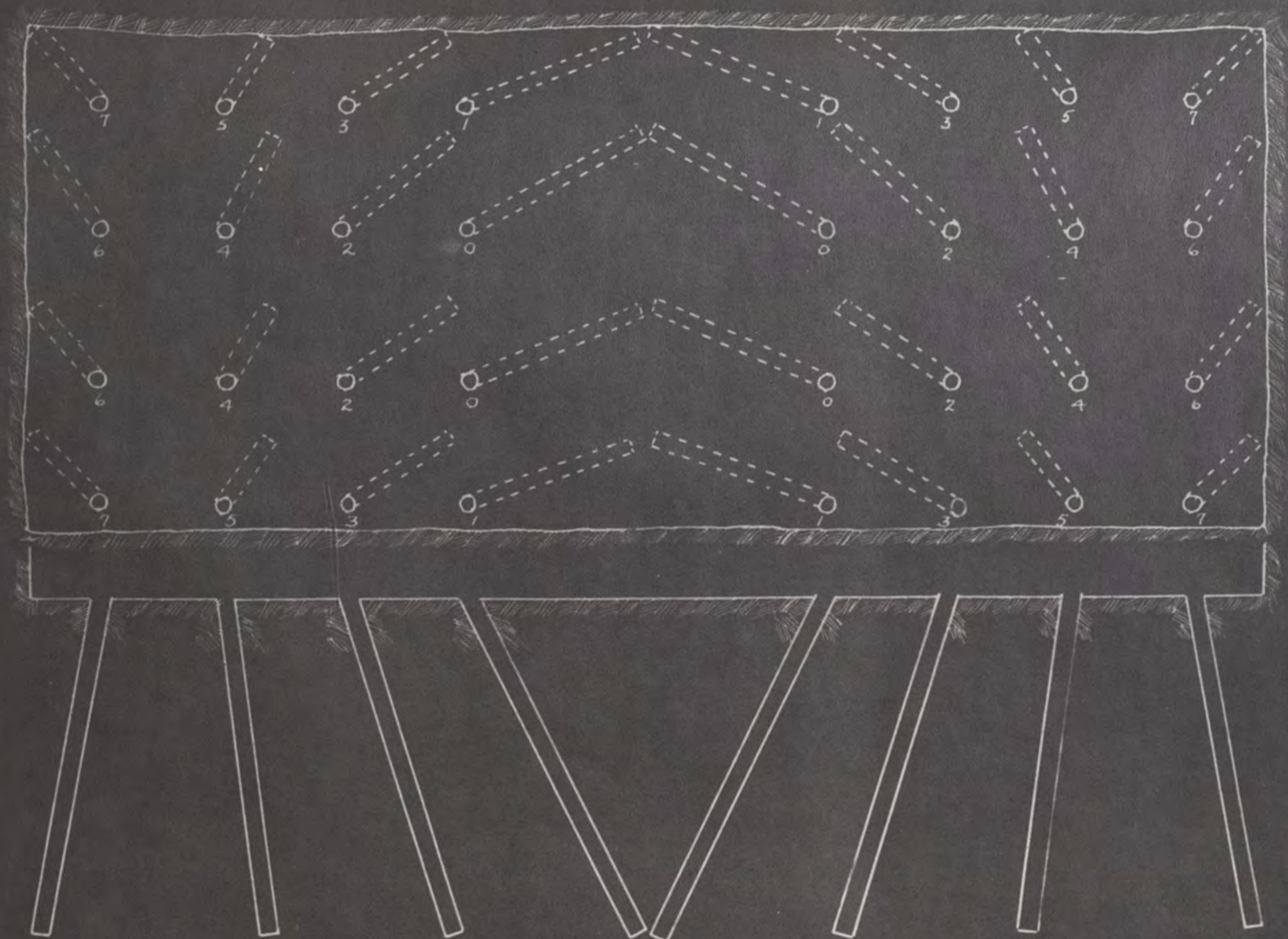
Section through C.F.Co Shaft 1934

Plate #1

the pilot winze, or 40 ft. below the 2700 level. The shaft round consisted of 32 holes drilled with four drifters mounted on two cross bars. A 5-1/2 ft. round was drilled employing V-type cuts. (See Plate #2). The holes were loaded with 50% Straight Gelatin, and fired electrically with current from the 260 volt D.C. trolley wire on the 2700 level. The blasting switch was a Square D type switch box having a handle on the outside for manipulating the switch. When the switch was not in use, the handle was kept locked to a lug on the box to prevent tampering. As a further precaution, a similar type box was placed in the circuit ahead of the blasting switch. It was to prevent current entering the blasting line prematurely. The procedure in making a blast was to throw this safety switch to complete the circuit, then to throw the blasting switch. After each blast both switches were locked, the keys remaining with the boss on shift. One hour before blasting time the electrician tested the blasting line, then remained with the shift boss to check the connections of the loaded round. The holes were fired in eight delays from a parallel circuit.

When the shaft reached a depth of 100 ft. below the 2700 level we removed the 10 ft. pillar left in the shaft below the ore pocket, and hung heavy wooden doors in the two hoisting compartments in its place. The doors were kept open excepting when the skips were loading from the pocket.

One hundred and ten feet below the 2700, the shaft cut a fissure from which flowed several hundreds of gallons of tepid water per minute. We had anticipated encountering water so had



V Cut Round used in Sinking the Carlos Francisco Shaft

R. A. M.

Plate #2.

prepared for it. On the 2700 level, we had a #5 and a #11 piston-type Cameron air pump mounted on trucks for lowering on the skip track. Each pump was provided with a steel cable having a shackle on one end for connecting to the ring bolt on the bottom of the ore skip. The pumps were equipped with rubber suction and discharge hoses, 4 in. in diameter and 15 ft. in length. In addition to the permanent air and water lines in the shaft, we had placed two 4 in. pipes for carrying any shaft water to the drainage ditch on the 2700 level. Therefore, to begin pumping, we only had to lower the pumps and to connect the discharge hoses to the 4 in. discharge lines. The only appreciable delay caused in the work by the water was when making a blast. To raise the pumps to a safe place, allow sufficient time for the smoke and gas to leave the shaft, and lower them into position again, required 40 minutes, during which time the water in the shaft rose from 12 to 15 ft. To lower the water sufficiently to resume work, required an additional 50 minutes so that an overall delay of 1-1/2 hours was unavoidable. The two Cameron pumps were later replaced with a direct connected Krogh centrifugal pump.

Sinking continued, and when the shaft reached a depth of 25 ft. below the position of the 2900 level, the work was stopped and this station was cut out and timbered. At that time we received two Byron-Jackson direct connected centrifugal pumps to replace the Krogh pump. Since none of our pumps could operate against a head greater than 200 ft.,it was necessary to install a booster pump on the 2900 level. The Krogh pump was used for this purpose. From the rear of the station, and towards the vein, a crosscut 100 ft. in length was driven to provide room for a sump. The crosscut was dammed at the mouth with a concrete wall to form the sump into which the shaft pumps discharged. A concrete water ring was poured 15 ft. above the 2900 level to trap the water flowing from the fissure and by-pass it to the sump. Although it was impossible to trap all the water, we did succeed in catching from 30 to 40% which relieved the shaft pumps. A small construction hoist was installed on the 2900 level to facilitate handling the shaft pumps and to relieve the main skips of this duty. (See Plate #3)

The shaft work was restarted, but with hand held drills replacing the mounted drifters. We had started the work with drifters because it was the only one with which our machinemen were familiar, but while sinking the first 54 meters I had been breaking them in to use the hand held drill. With the latter type machine we were drilling within one hour from the time we commenced to connect the machines against three hours using the mounted drifters. Since there were no hand held machines in the mine capable of drilling the andesite, eight of the drifters formerly used were converted. The handles were made in the machine shop. The work progressed without further interruption to 25 ft. below the 3100 level. Just above this level we had cut another fissure but it had caused no delay in the work. The only difference being that the water now flowed from this fissure leaving the one above the 2900 level completely dry. The 3100 level was cut and timbered, and as on the 2900 level, a crosscut was driven towards the vein for a sump. For the booster pumps, we installed two four stage, direct connected, centrifugal pumps capable of operating against a

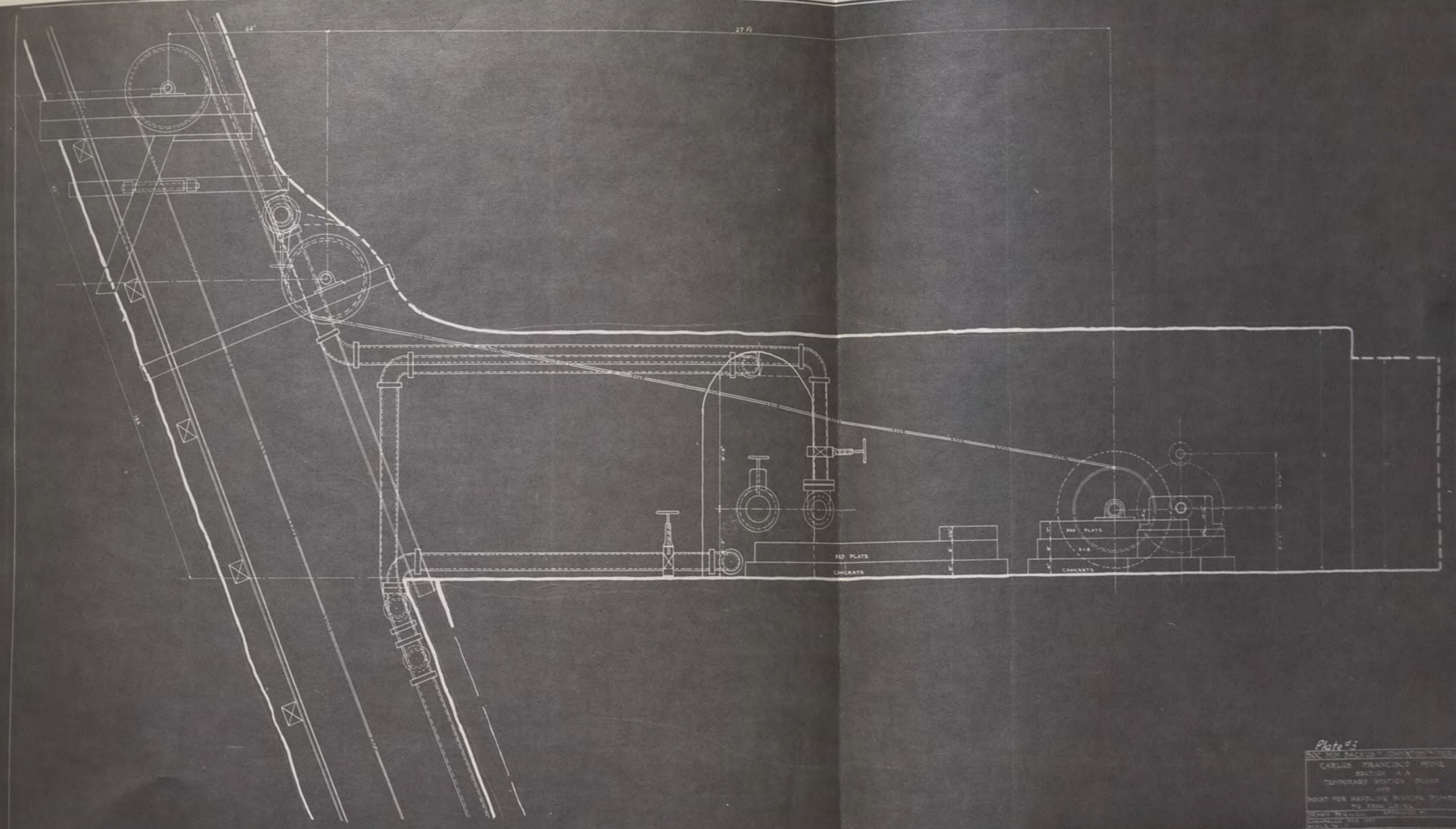
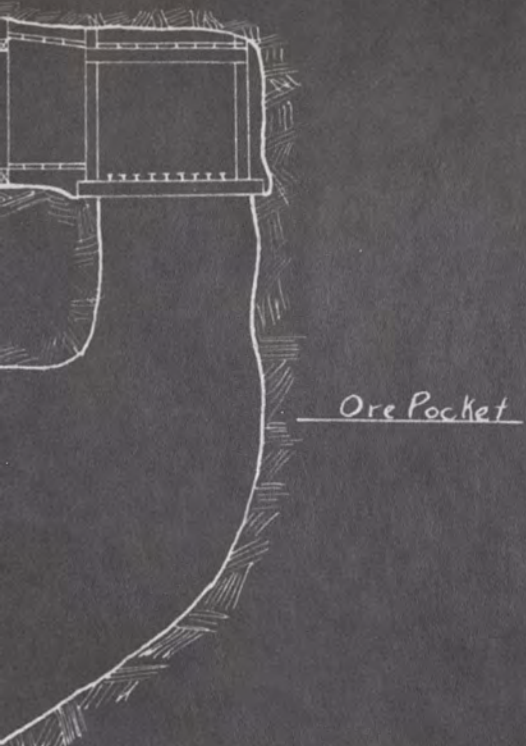

27 Ft
BED PLATE
CONCRETE
CONCRETE
CARLOS FRANCISCO MINE
SECTION A-A
TEMPORARY STATION PUMP
AND
HOIST FOR HANDLING SINKING PUMPS

Plate #3

550 ft. head. One was a Cameron with a capacity of 1000 gallons per minute, and the other was a Worthington having a capacity of 2500 gallons per minute. With these two pumps installed we could pump direct to the 2700 level, therefore we no longer needed the Krogh pump on the 2900 level. A water ring was poured in the shaft above the 3100 level and the trapped water was by-passed to the sump. The shaft was now completed to a depth of 108 meters below the 2700 level.

Sinking was resumed, and continued to a point 25 ft. below the position of the 3314 level. Although we had again cut fissures, we lost no time from the extra water. The fissures above drained, and in a short time the 3100 level became dry. The only change in the work was that 80 ft. below the 3100 level the shaft passed out of the andesite into silicified red shale. From the contact down it was necessary to timber the hanging wall of the shaft. A small station was cut and timbered at the 3314 level for landing the pumping equipment, then the 3300 level station was cut and timbered. From the rear of this station a crosscut was driven 80 ft. to the south, or away from vein for a sump, and later to provide tailroom for the electric trains. To the north we drove a crosscut for 80 ft. merely to get this side started towards the vein and away from the station. The Krogh pump was brought from the 2900 level and installed on the station to boost the water to the 3100 level sump. A Worthington pump, similar to the one on the 3100 level was installed as a stand-by pump. Another concrete water ring was poured in the shaft above the 3300 level before resuming work in the shaft.

We continued sinking until the desired depth of 192 meters below the 2700 level had been reached. At 60 ft. below the 3300 level we cut and timbered a 150 ton pocket which connected with the rear of the 3300 station. Air gates were installed on each of the three main chutes and measuring pockets to enable the two main skips and the sinking skip to load from it. A small permanent sump pump station was cut out 15 ft. above the bottom of the shaft to accomodate the two Byron-Jackson pumps. (See Plate #4 showing the relation of the work done below the 3300 level). The shaft was now completed and each shaft crew was split into two sections. One section started the crosscut from the 3314 level station to the site of the pump station, and the other re-started the crosscut from the 3300 level station to intersect the vein, as the position of the vein had to be known to establish the positions of the two concrete bulkheads shown on Plate 11-F-34.



Sketch showing positions of
3300, 3314 Levels, Ore Pocket,
Loading Chutes and Sump
Pump Station

Not drawn to scale -

R.H.M.

Plate #4.

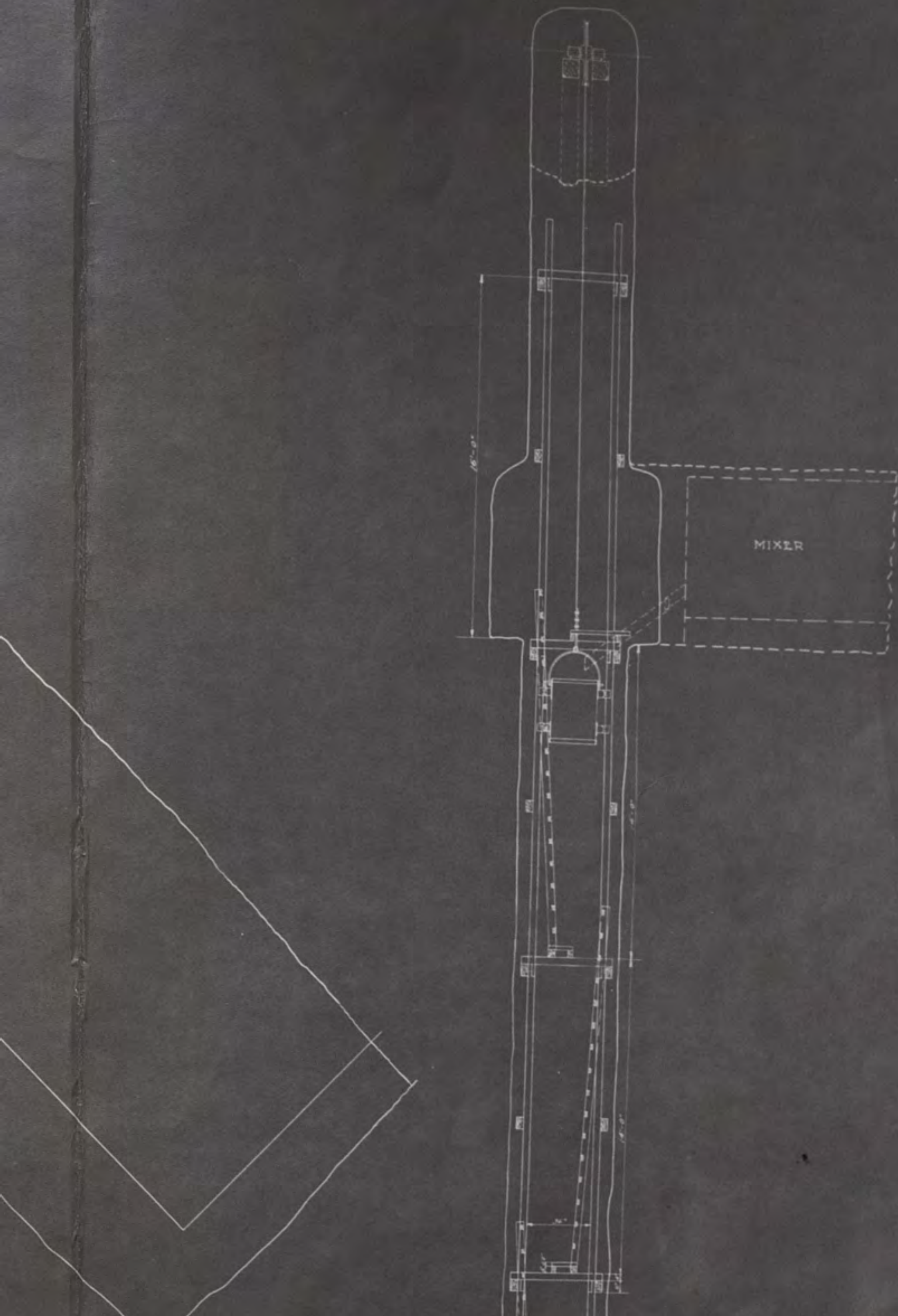

3300 Level
3314 Level
Loading Chutes
Sump Pump Station

3314 Level Pump Station

The proposed 3314 level pump station was to be 165 ft. in length, 18 ft. in width, and 15 ft. in height inside of timber. The station was to accomodate seven, four stage Worthington pumps placed in line, and one Worthington sump pump placed to one side. Each of the seven station pumps had a rated capacity of 2500 gallons per minute against a 550 ft. head, and the sump pump a capacity of 500 gallons per minute against a low head. All were direct connected centrifugal type pumps. (See Plate #11)

Before any work was started on the pump station proper it was necessary to drive a short crosscut from the shaft station to the pocket through which to dispose of the waste rock from the pump station excavation. (See Plate #4) Then a 5 ft. by 7 ft. pilot crosscut 192 ft. in length was driven on engineers' lines from the 3314 shaft station to define the west wall of the pump station. At a point in the crosscut 30 ft. from the shaft station another crosscut was driven to the east wall to outline the pump station on two sides. Using mounted drifters the station was cut out to its full length and width but to a height of only 7 ft. The height of the first cut was held to 7 ft. as a safety precaution. The station was cut in red shale with the bedding at a steep angle, a condition made worse by much cross fracturing and a heavy drip of water. By carrying the first cut at a height of 7 ft., any dangerous ground could be easily supported with light stulls until we were ready to break the back down to full height for timbering. All the broken rock from the excavation was handled with a boom type scraper loader operating with compressed air. The loader was built in

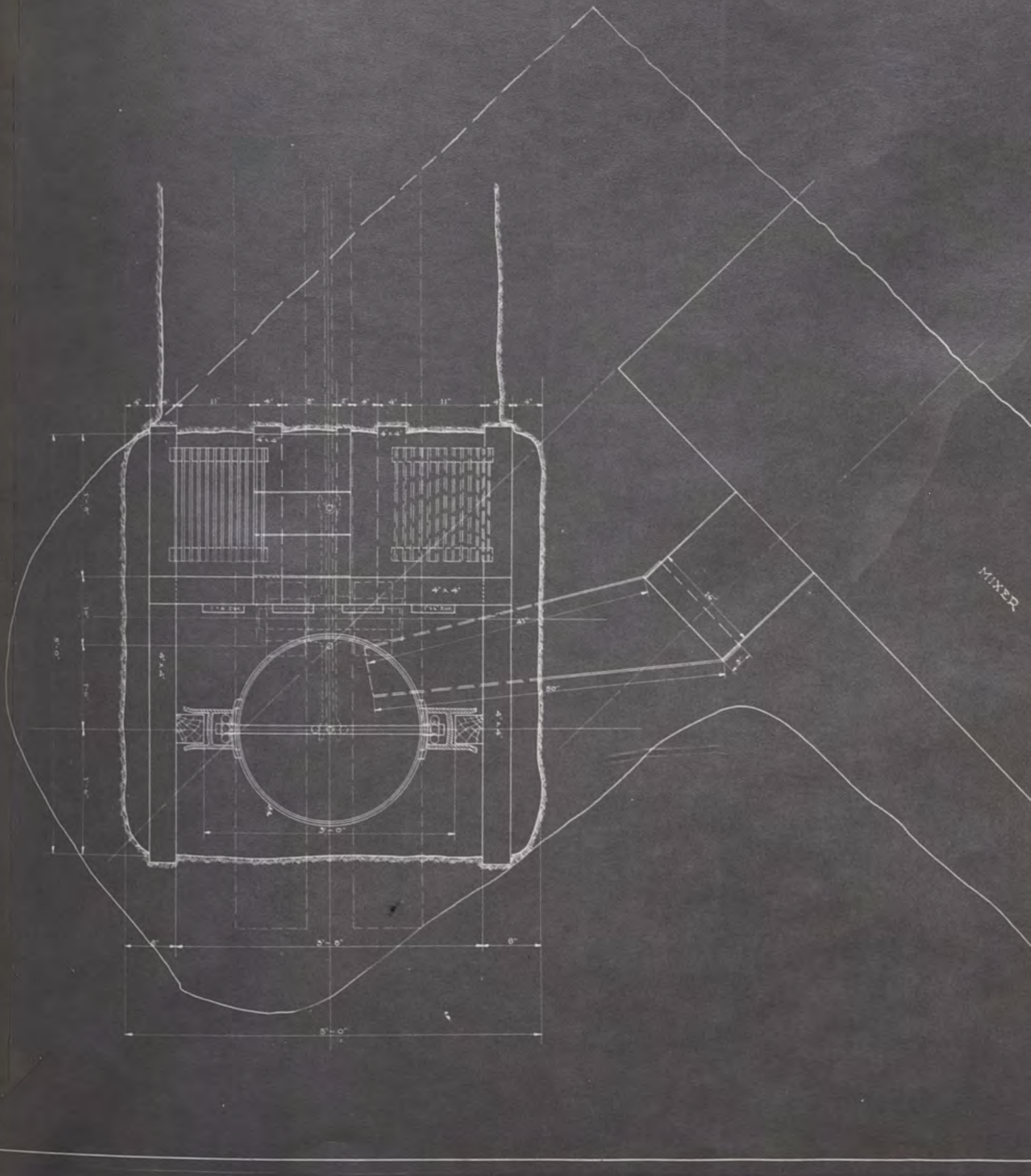
joists were six inches in width and a minimum of one foot in height. The piers for carrying the station sets were fourteen inches square, placed on five foot centers, each having a one

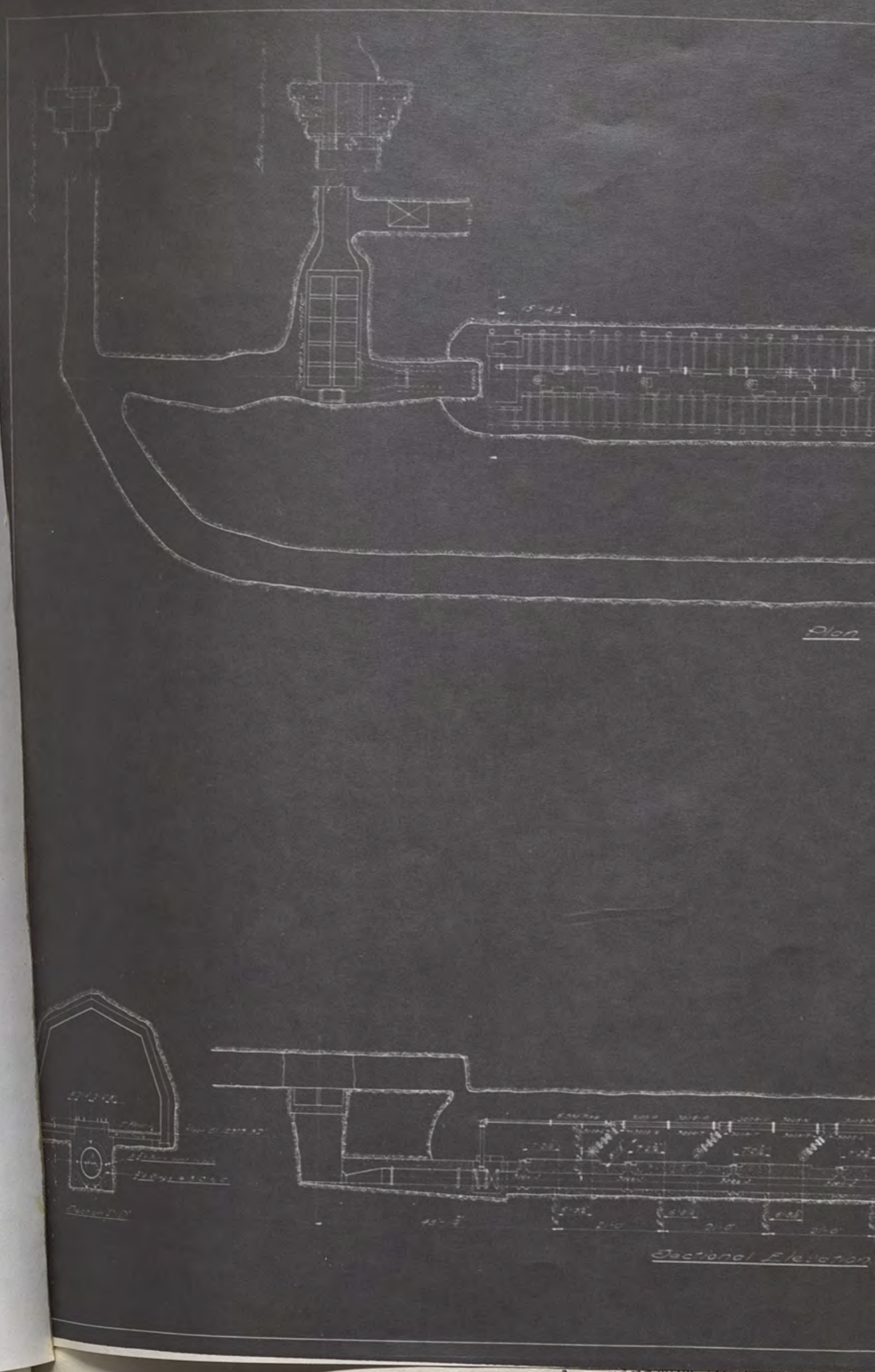


SOC. MIN. BACKUS Y JOHNSTON DEL PERU

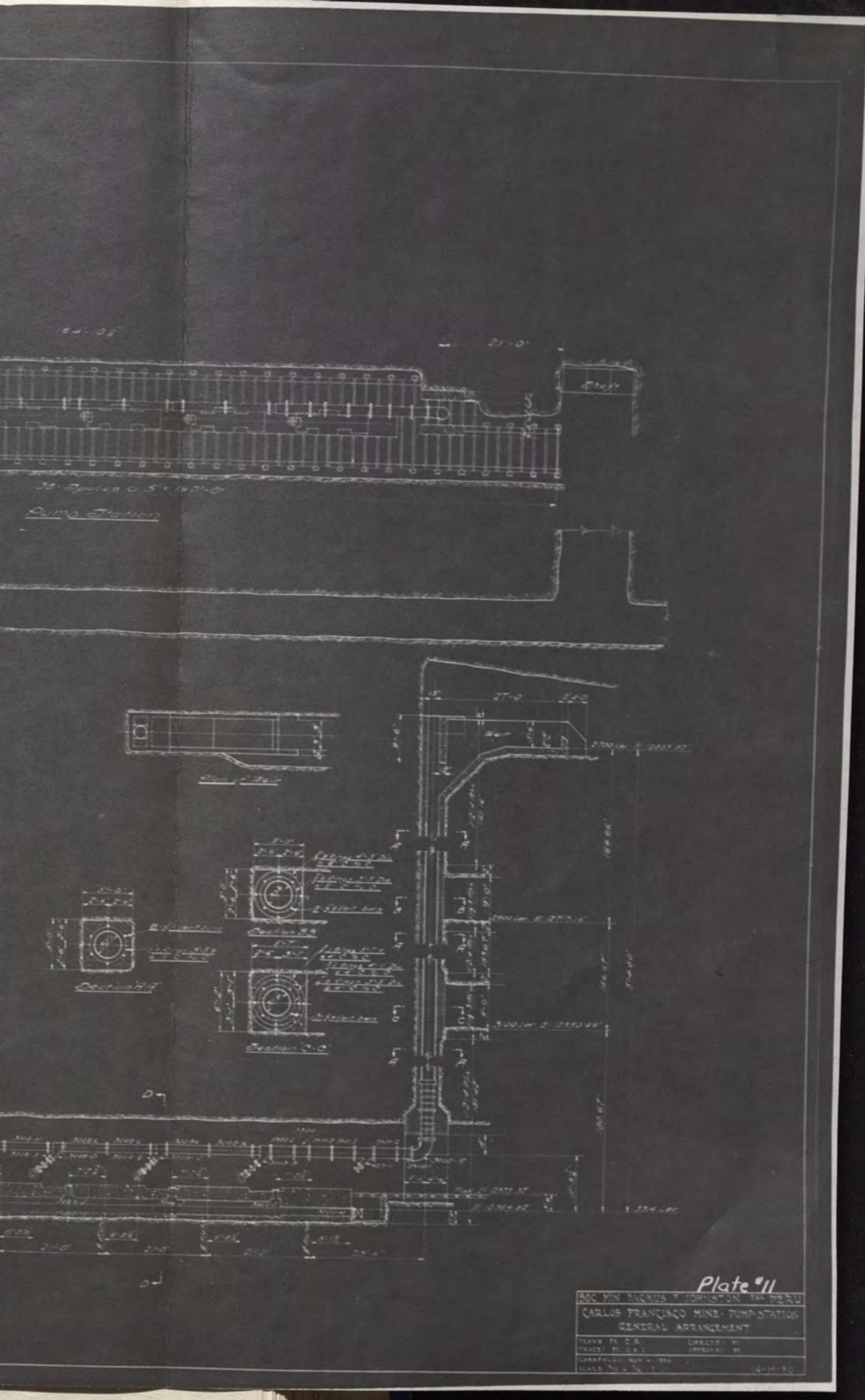
3314 PUMP INSTALLATION
WATER DISCHARGE COLUMN
ARRANGEMENT FOR CONCRETING

DRAWN BY	CHECKED BY
TRACED BY C.B.C.	APPROVED BY
CASAPALCA, JAN. 30- [illegible] SCALE [illegible]	3-E-30


MIXER
3'-0"
3'-6"
6"
3'-0"
4" x 4"
50"
41"
15"



joists were six inches in width and a minimum of one

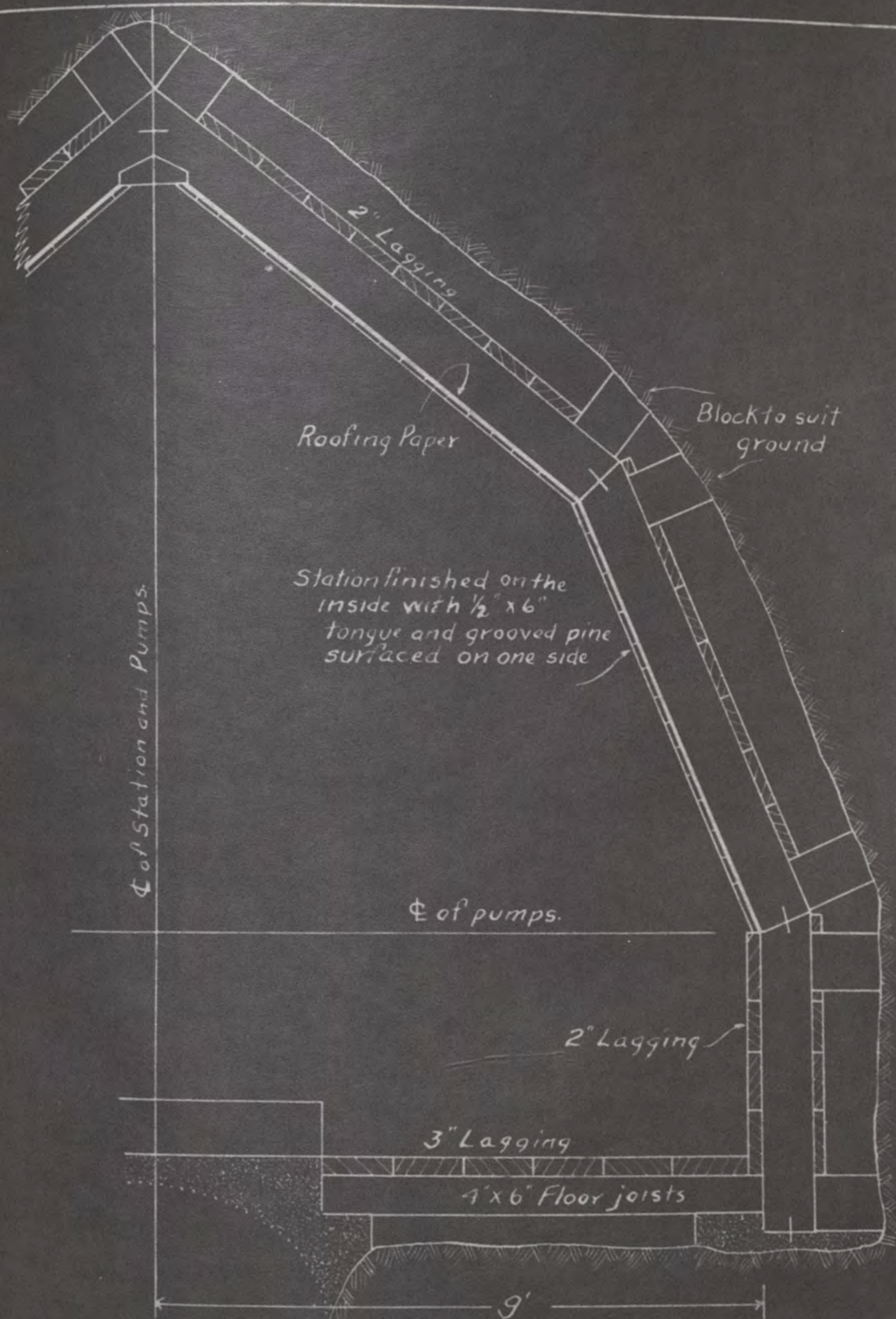


Pump Station
Plan of Main
Section A-A
Section B-B
Section C-C
Plate #11
SOC MIN BACKUS Y JOHNSTON PERU
CARLOS FRANCISCO MINE - PUMP-STATION
GENERAL ARRANGEMENT

our machine shop in small sections suitable for loading in the cages and for reassembling at the place where it was to be used. The loaders emptied into one ton cars which were hand-trammed to the pocket by two men. The speed of loading was influenced by the size of the broken rock and the position of the loader. If the broken rock were of small sizes, or if the loader were in the center of the excavation, mucking would be much faster than if the broken rock were of large pieces, or if the loader were placed along a wall. The first condition is self-explanatory. In the second condition the position of the loader affects the speed of loading in this manner: (1) a loader works most efficiently when the scraper can be kept working in a trough rather than scraping at random, (2) when the loader is away from the wall men can be placed on both sides of the trough so that they may be continuously pushing broken rock in the path of the scraper. Although on several occasions we loaded as high as 80 cars in an 8 hour shift, the average was between 50 and 60 cars.

The next operation was to cut out for the intake pipe which required an excavation 5 ft. by 6 ft. in the floor of the pump station. Simultaneously with this operation carpenters were building forms for the reinforced concrete walls and piers which were to be used for carrying the station timber. When all blasting for the intake pipe excavation was finished, and while the broken rock was being removed, the concrete for the walls and piers was poured. The walls for carrying the floor joists were six inches in width and a minimum of one foot in height. The piers for carrying the station sets were fourteen inches square, placed on five foot centers, each having a one inch dowel pin in the concrete for anchoring the upright posts of the sets. After the concrete had set, the walls and piers were well covered with broken rock and heavy timber to protect them from falling rock when we commenced to blast the back of the station down for timbering. Since the water discharge column turned vertically at the south end of the pump station, the excavation for it was driven to get it out of the way before any timber work was attempted in the pump station proper. Six men from each shift were assigned to continue driving this raise to the 3100 level. From the 3100 to the 2700 level the work was done on contract by men from other sections of the mine. One contractor drove the raise from the 3100 to the 2900 level and another from the 2900 to the 2700 level.

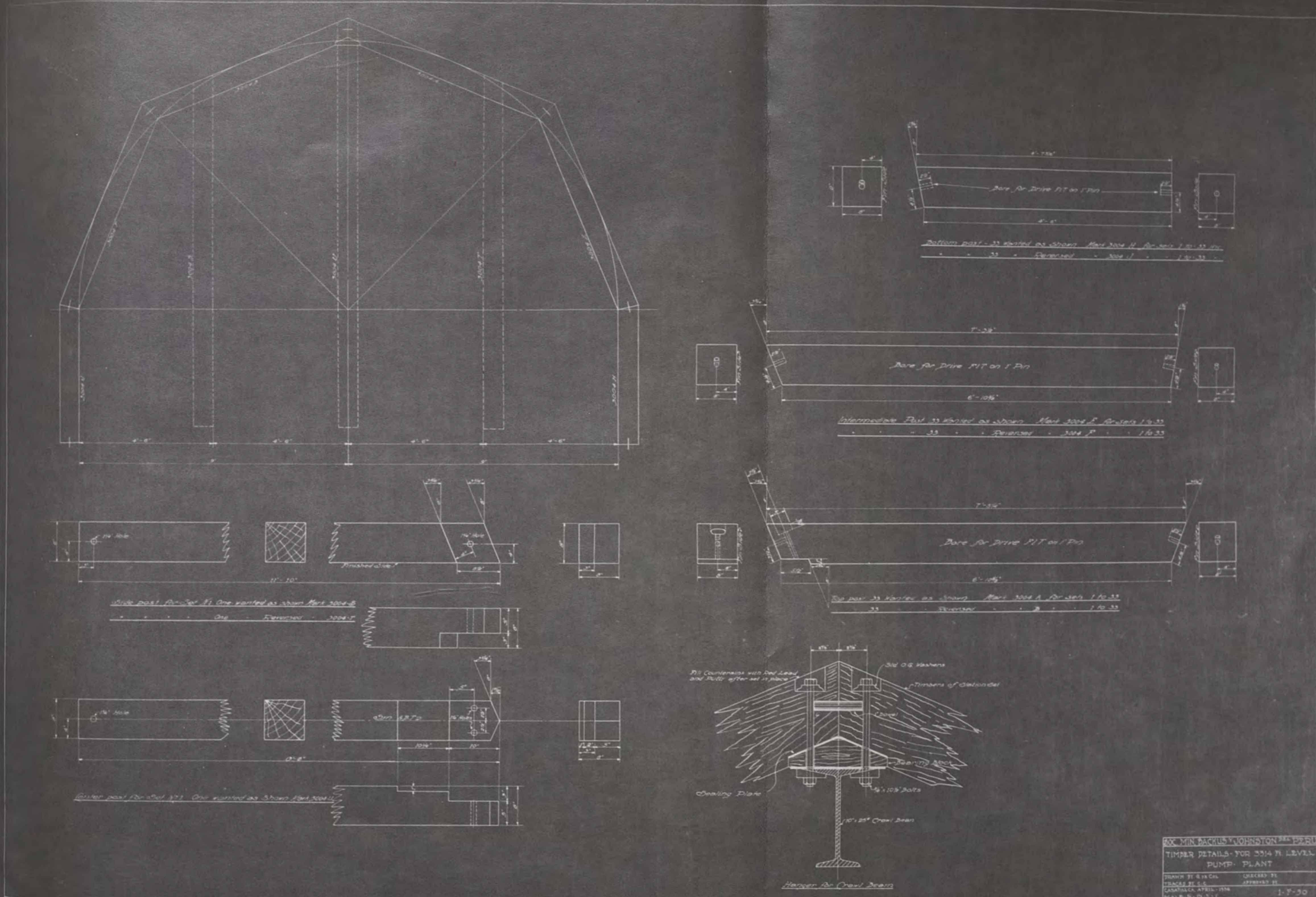
With the water discharge raise out of the way we were now ready to start standing the station sets. The station was to be timbered with 33 six piece segmented sets made of 8 in. by 8 in. Oregon pine. They were framed and fitted to templates in the carpenter shop outside and sent to the mine as needed. The sets as well as the individual segments were numbered in order that all the pieces would be used in their proper sequence. We had originally planned to use stopers for breaking down the back of the station preparatory to timbering, but the ground was too blocky and it overbroke. However, to make room for the first three sets, we were forced to use stopers, and later we changed to mounted drifters. Instead of removing the broken rock from the first three blasts we left it in place to serve as a platform from which to work. By working from the top of the muck pile we could easily place the twelve blocks required for each set. Also, when it was necessary



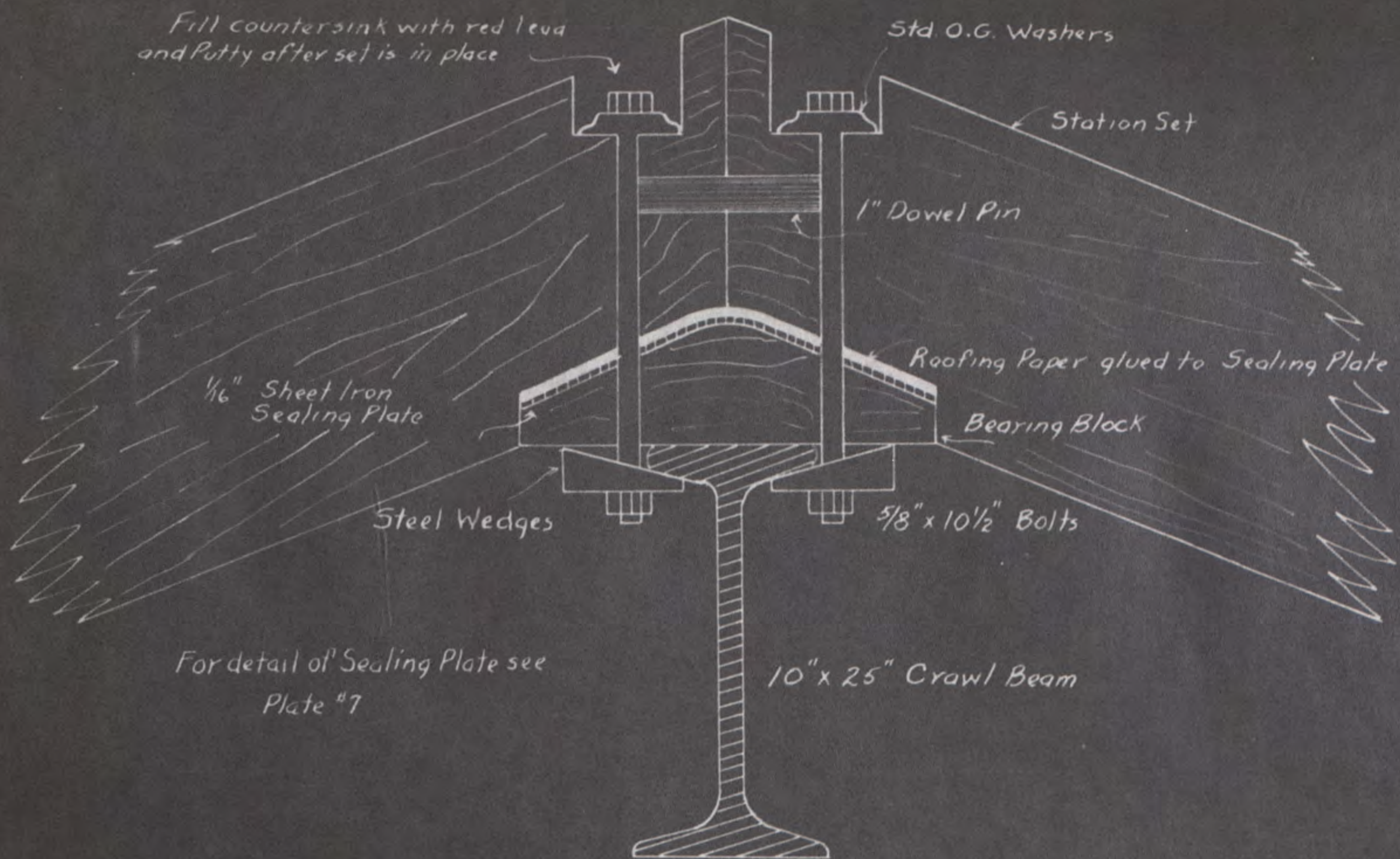
Part cross section of a Typical Set showing Lagging and Lining

R.H.M.

Plate #5


Bore for Drive FIT on I Pin
Hanger for Crawl Beam
Sealing Plate
SOC. MIN. BACKUS Y JOHNSTON DEL PERU
TIMBER DETAILS - FOR 3314 FT. LEVEL
PUMP - PLANT
CASAPALCA APRIL - 1936
1-F-50

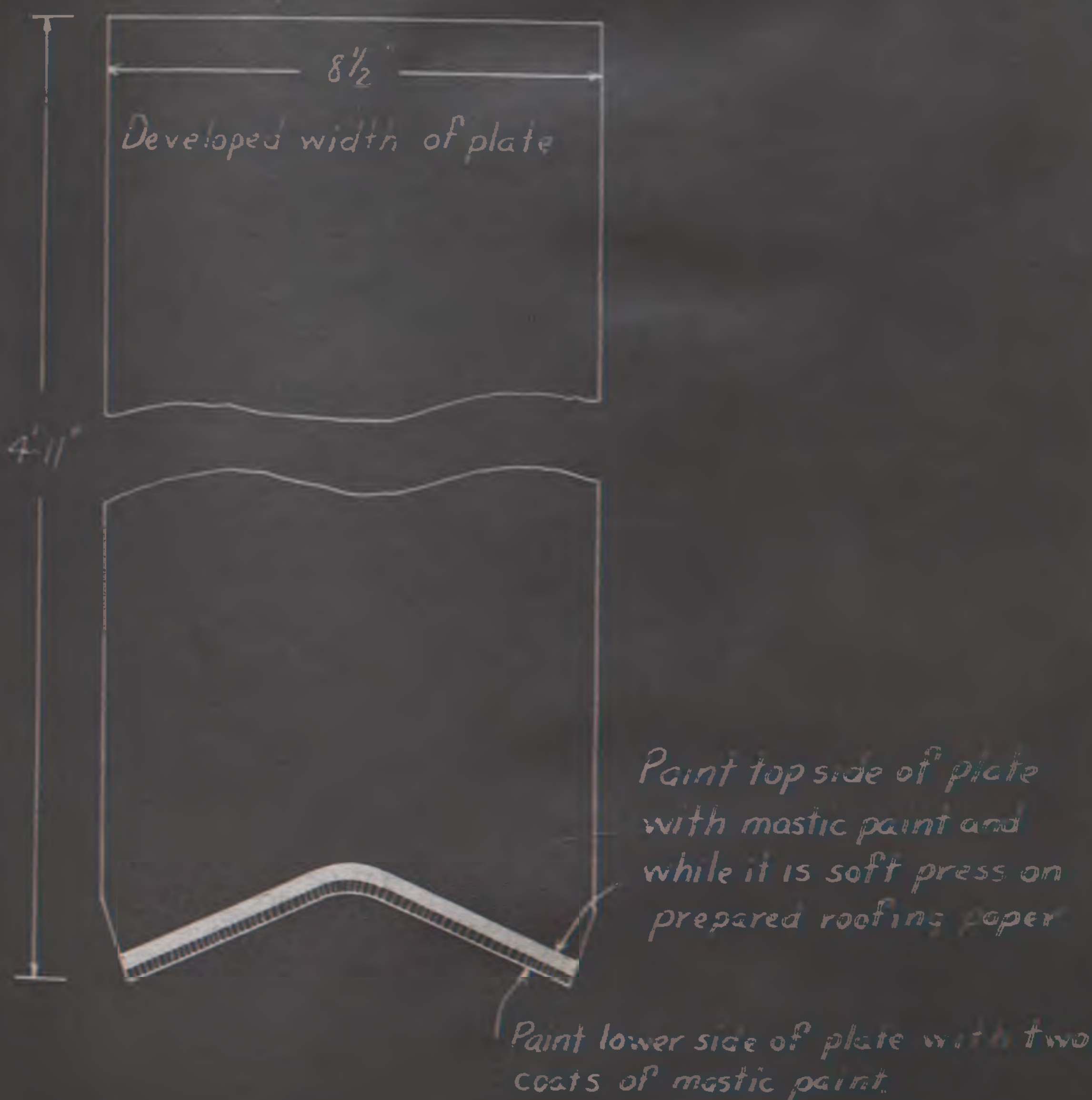
to break down ground ahead for the next set, we could set up the drifters on top of the muck pile, thus blocking the machine column to the crown of the last set stood. Using mounted drifters proved better for three reasons: (1) It was safer for the machinemen because they always worked above the brow of the unbroken station back, and under the protection of the last set stood; (2) we could drill horizontal holes and control the breakage; and (3) we could carry our timber within three feet of the unbroken brow because the horizontally drilled holes broke down and away from the timber. Standing and blocking the first three sets puzzled the crews a little but after each shift had stood and blocked a set the men got the hang of it. The difficulty was with the blocking because with segmented sets the blocking must be done evenly all around the set. If the blocking were wedged too tightly on one side the segments on the opposite side opened, or if the blocking at the top of the set were too tight the whole set slumped,opening all the segments. After we had stood and blocked the first three sets the engineers checked them for line and grade and established permanent lines for standing the other sets. Although we had checked the concrete piers on which the sets were stood and knew them to be correct for line and grade this second check was to pick up any error in the framing or in the dimensions of the timber itself. This precaution was taken to avoid difficulty when hanging the 10 in. crawl beam from the crown of the set. (See Plate #6 for the position of the crawl beam) If the sets had not been in line, or if they had been blocked unevenly, it is not difficult to forsee the trouble we would have had hanging the crawl beam. Continuing by engineers'



Method of Supporting Crawl Beam and Waterproofing Station Sets

R. H. M.

Plate #6



Sealing Plate for Station Sets
For Location see Plate #6

Not drawn to scale

lines we stood the remaining sets and had no difficulty hanging the crawl beam.

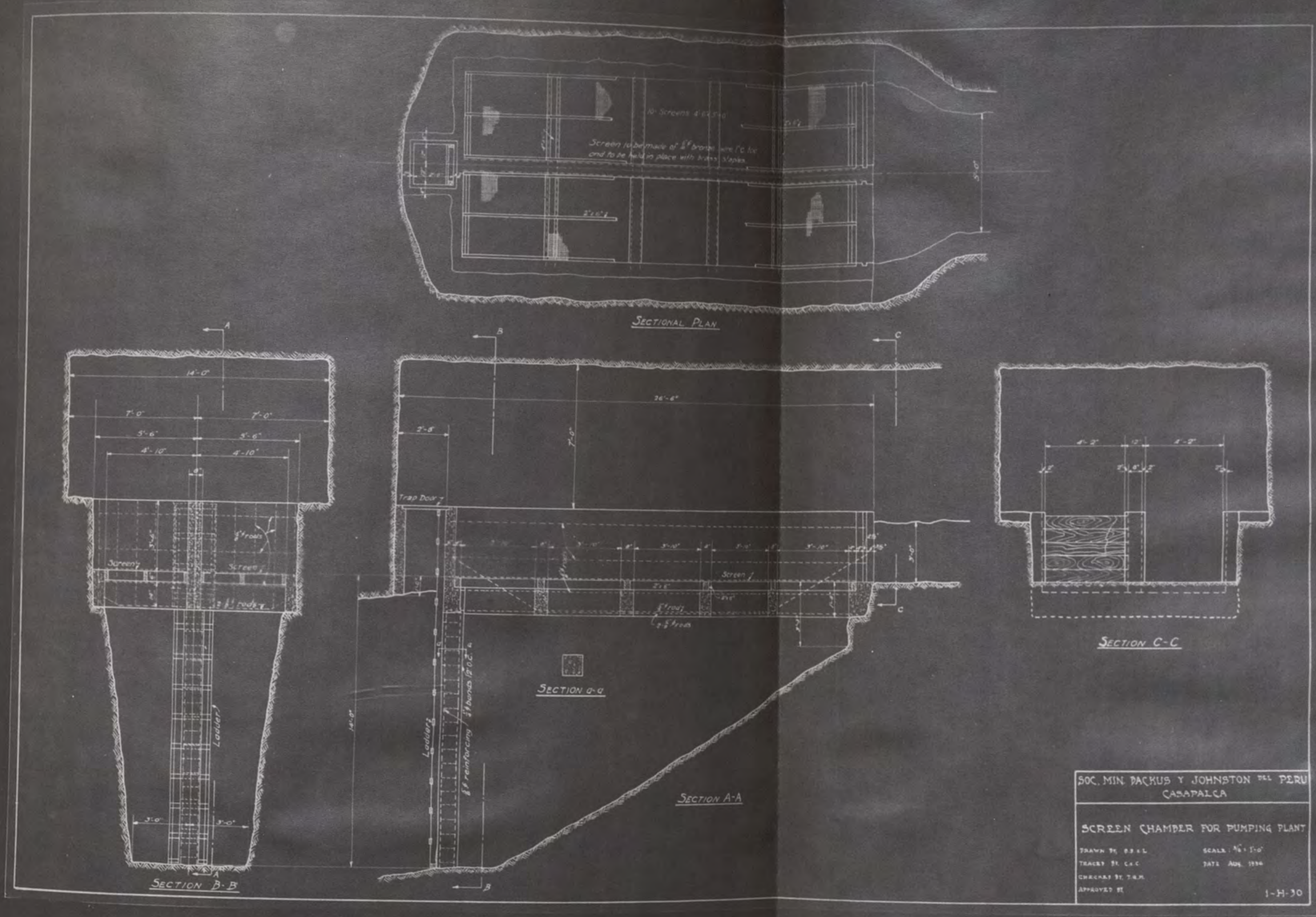
The position of the crawl beam at first complicated our job of waterproofing the station sets, but this was solved. The method adopted was to cut #20 gauge black steel sheets in pieces 4 ft. 11 in. in length by 8-1/2 in. in width. These dimensions corresponded to the distance between the 5/8 in. by 10-1/2 in. bolts in each set for supporting the crawl beam, and the length of the bearing block in the crown of the set. (See Plate #6 for the position of the sealing plate) The top side of each sheet was given two coats of heavy mastic paint and while the paint was still soft, heavy prepared roofing paper was pressed on. Before the 15 ft. sections of the crawl beam were hung in place these sealing plates were slipped into their position on the top of the bearing blocks, and brought up tight against the set when the wedges supporting the crawl beam were tightened. After each section of the crawl beam was hung in place, the notches cut in the top of the set for the bolts supporting the crawl beam were filled with a mixture of red lead and putty to prevent leakage at this point. When all the sections of the crawl beam were in place we welded the joints to form one continuous beam.

The outside of the sets was tight lagged with 2 in. by 12 in. pine lagging. (See Plate #5) The inside of the sets was finished a little differently. From the floor to the first inclined segment the inside of the sets was finished with 2 in. by 12 in. pine lagging surfaced on one side, and from this point to the crown of the set with 1/2 in. by 6 in. tongue and grooved pine flooring. However, before the flooring was nailed into place the inside of the sets was lined with heavy roofing paper. This completed the job of timbering and waterproofing the station.

The last excavation to be made in the pump station was that for the concrete union between the screen chamber and the intake pipe in the pump station. It was a small excavation requiring but three days to finish. (See Plate 10 for the construction details and Plate # 11 for the location of the union.) Between the union and the intake pipe was to be installed the gate valve controlling or shutting off completely the water from the screen chamber.

Meanwhile, the other crew working on the 3300 level had made excellent progress. They had finished driving the main haulage crosscut (8 ft. by 8 ft.) to intersect the vein, had crosscut to the site of the screen chamber, had driven the crosscut from the screen chamber to the vein in which was to be placed the concrete bulkhead with valves, and had started the 5 ft. by 8 ft. ventilation raise. This crew was split into two sections; one section to continue driving the ventilation raise, and the other to make the excavation for the screen chamber.

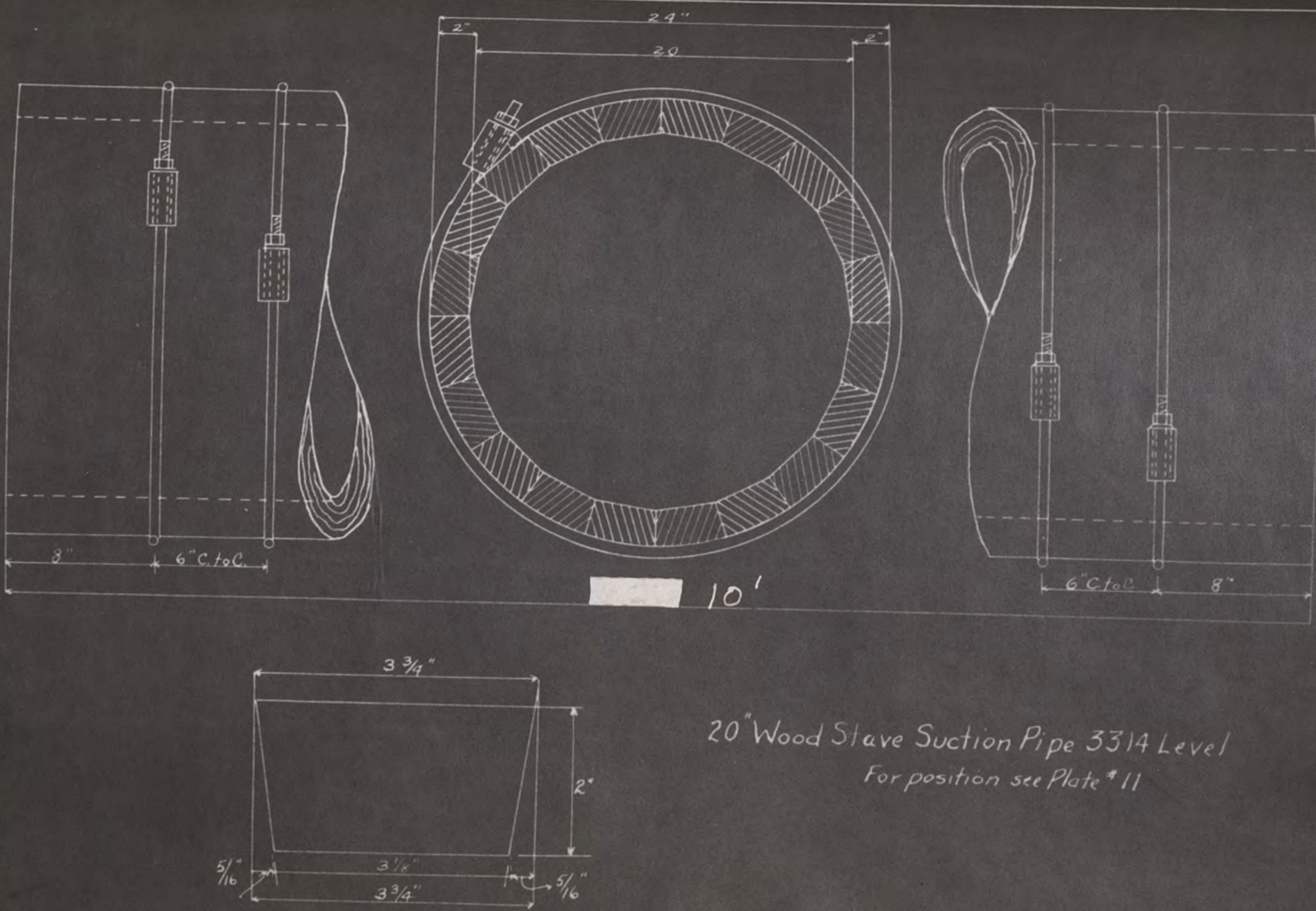
The site of the screen chamber was not a good one because it was on a contact between the red shale and a conglomerate. However, we had no choice and had to go ahead as originally planned since the pump station, already completed, and the bulkhead for the valves determined the location of the screen chamber. The excavation was difficult to make because the


Sectional Plan
Section B-B
Section A-A
Section C-C
Section a-a
Trap Door
Ladder
Screen
SOC. MIN. BACKUS Y JOHNSTON DEL PERU
CASAPALCA
SCREEN CHAMBER FOR PUMPING PLANT
1-H-30

ground was blocky and overbroke in spite of every precaution taken to prevent it. We finally had to put in concrete retaining walls along each side, although this was not included in the original plans. The object of the screen chamber was to remove all the small bits of wood from the mine water before it reached the pumps. It was designed to have two sections so that by means of control gates one side was in use while the other side was being cleaned.

The ventilation raise was located to one side of the crosscut which connects the screen chamber to the vein. It was driven 5 ft. in width by 8 ft. in length to permit 40,000 cu. ft. of air to pass per minute. This was the amount of air necessary for ventilating the pump station when it was in operation. We drove the raise from the 3300 to the 3100 level. From the 3100 to the 2700 level it was driven by crews from other sections of the mine. After the raise had been driven all the timber was stripped from it.

With so much concrete work to be done naturally the problem of sand and gravel came up. We had lowered sufficient sand and gravel in sacks from the 1700 to the 3314 level to take care of pouring the concrete for the intake pipe and the pump and motor bases but this was occupying the cages for work for which they could hardly be spared. We knew that we would have to continue lowering the sand for all the concrete work in this manner for there was none available inside the mine, but if rock suitable for gravel could be found inside the mine, it would save us many hours. Fortunately, at this time we were enlarging the drainage ditch from the Carlos



20" Wood Stave Suction Pipe 3314 Level
For position see Plate #11

RHW

Francisco mine to the Aguas Calientes mine to carry the extra water from the water discharge column. As this rock was barren and hard, samples of it were sent to the testing laboratory maintained by the company at La Oroya. The report came back that it was suitable for concrete work, and a small jaw crusher was set up in a convenient spot on the 2700 level to crush all the waste rock from the ditch. The ventilation raise near the screen chamber was used to store the gravel for the two concrete bulkheads. When sufficient gravel had been produced for this work, we continued crushing and sizing gravel for use in concreting the water discharge column. Since the concrete for this job was to be mixed on the 2700 level, the gravel was stored in an abandoned drift on that level. The sand for all the concrete work was brought in from the stock pile outside the mine and lowered in the cages to where it was to be used. The sand for the two bulkheads was stored on the 3300 level, and that for the water discharge column in an abandoned drift on the 2700 level. This work occupied about three months time.

In the meantime a one half yard concrete mixer was brought down to the 3314 level. The smaller pieces were brought down in the cages, and the base was lowered on top of the skip. The drum was too large either to go in the cage or to be lowered on top of the skip so it was slung underneath a skip and slowly rolled down the skip track from the 1700 to the 3314 level. While the mixer was being assembled in the pump station, the carpenters were putting together the 10 ft. sections of the wood stave intake pipe. The staves for it had been cut and framed in the carpenter shop. (See Plate #8 for construction details and Plate #11 for position) ,The small pipe shown to one side of the wood stave intake pipe was not used. Although Plate # 8 shows a section of wood pipe 20 in. in diameter, the final section adopted was increased to have an overall diameter of 36 in. All other details remained as shown. The sections of pipe were assembled in the pump room to avoid having to lower them in the cages. As fast as they were assembled, they were laid in position. The forms for the pumps and motors were built and the reinforcing iron for the entire job was put into place, but before any concrete was poured the engineers checked all the construction details. The concrete mix was in the proportion of 1-1½-3, and the maximum sized gravel used was 1½ in. After the concrete had set, the forms were removed and the station flooring was put in. The pump station was now ready to receive its equipment.

Of all the jobs to confront us, that of lowering the pumping equipment was the most tedious and irritating. Having an inclined shaft to contend with only complicated it. The pumps, motors and much of the accessories were too large to enter the cages, and the shaft did not have sufficient clearance on the hanging wall to allow them to be lowered on top of the skip, therefore, the only solution was to construct platform trucks and lower them on the skip track. The machine shop made steel platform trucks for operating on the skip track. Each truck was equipped with heavy steel straps to hold the piece being lowered in position. The pieces were slung underneath the ore skips and lowered on the skip track to the 3314 level.

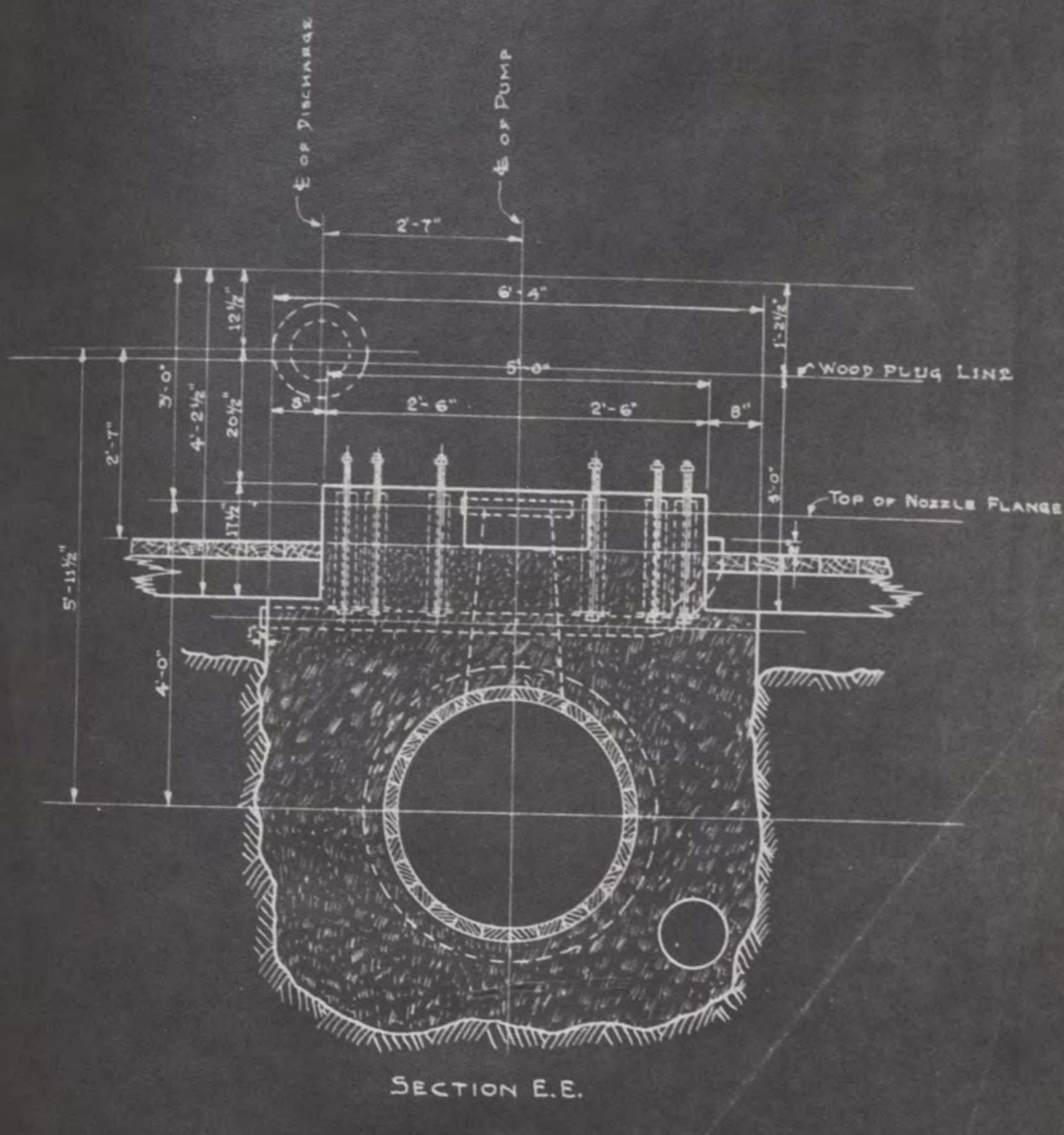
Since the skips and cages were only available for this work on Sundays the work had to be planned accordingly. During the week, each piece to be lowered on Sunday was strapped to its truck. This was done in the machine shop rather than in the mine because of better facilities. All the pieces were sent to the mine late Saturday afternoon and unloaded on the 1700 station. The men who were to lower the equipment got everything ready Saturday afternoon so that they could take over the cages and skips immediately after the night shift came off work at 5:30 Sunday morning. Before any equipment could be lowered, it was necessary to take off the extension lips on the 2100 and 2700 loading pockets so that the pumps and motors could pass. Since the ore was usually all hoisted by 4:00 a.m., and taking off the extension lips only required an hour, night shift timbermen attended to this detail.

Each Sunday morning our first job was to place a heavy bulkhead over the shaft heavy enough to withstand the weight of whatever equipment that was to be lowered. The piece to be lowered was then pushed as close to the shaft as possible, and slung under the skip. This was done by making two separate slings with one inch cable, which passed around the object and through the thimble at the end of the hoisting cable. The loops of the slings were closed with four Crosby type clamps on each loop. One sling would have been sufficient, but two were used as a safety precaution.

Experience had taught us that if the piece to be lowered were not properly balanced under the skip, it would derail many times before reaching the 3314 level. For that reason we hoisted and lowered it slowly several times about 15 ft. to check for balance before attempting to lower it. The two most common causes of derailment were: (1) The sling was too short causing the front wheels of the platform truck to lift off the track each time the hoisting engineer applied the brakes. Since the piece had to be lowered very slowly, it was necessary for the hoisting engineer to be constantly applying and releasing the brake. Therefore, the piece would be lowered with a jerky, rocking motion which might cause a derailment if the sling were too short. Although the same motion was present with a long sling, most of the force of applying the brake was arrested by the cable itself before reaching the piece, and what force did reach the piece was insufficient to lift the front wheels of the truck from the track. (2) The piece was not hung from the center of the sling, therefore it was not properly balanced and would derail. This was remedied by pulling the piece back onto the station, loosening the Crosby clamps, and centering it. By taking the proper precautions on the 1700 level before starting down with a piece, we saved much time and energy.

The first piece of equipment that we lowered was a pump and due to many derailments we were four hours lowering it from the 1700 to the 3314 level. Later, we were able to do the same job in 40 minutes. To lower all the pumps, motors, bases, and accessory equipment for the pump station required seven months time.

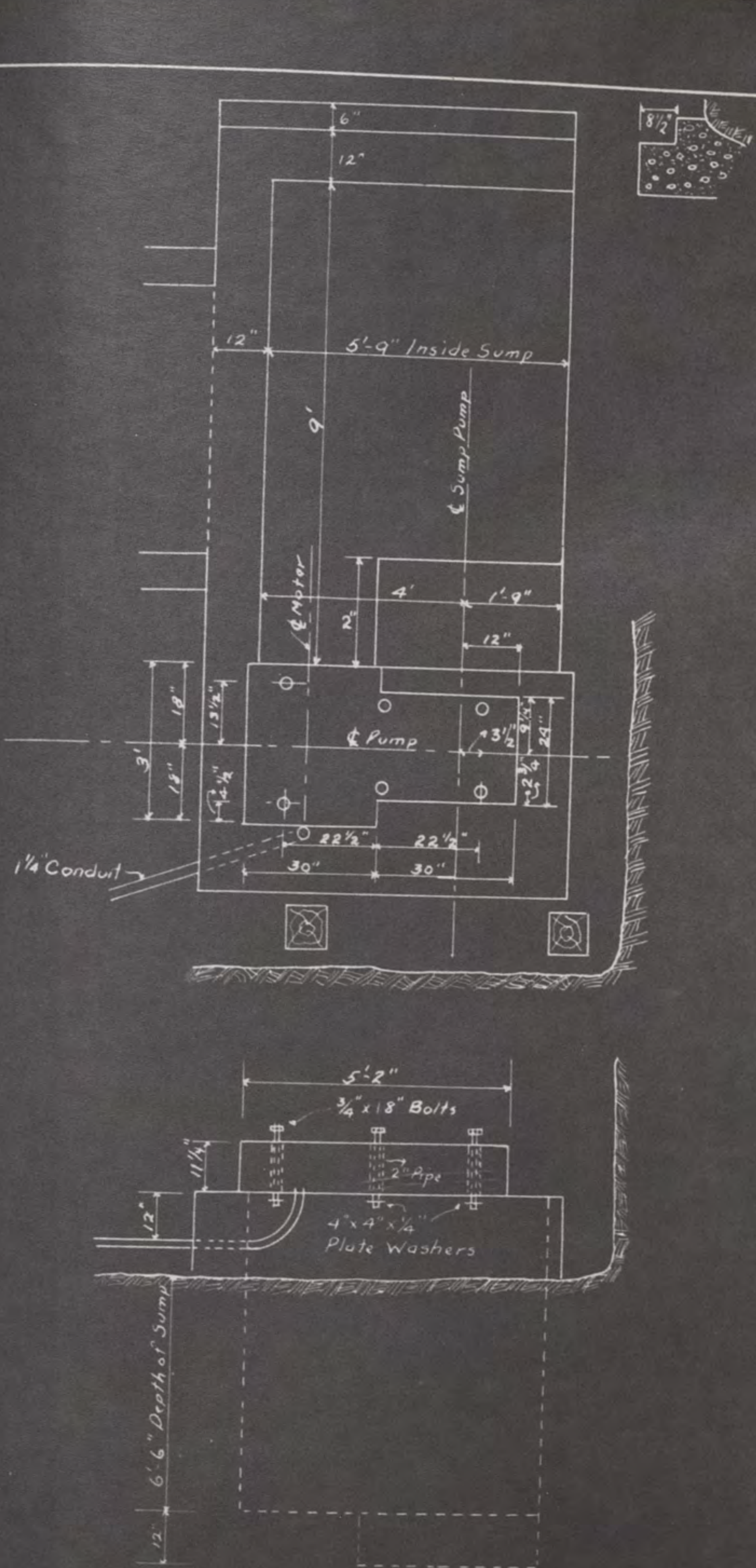
Assembling the equipment even after it had been landed in the pump station was not an easy job due to the lack of facilities for handling the heavy pieces. Of course the pumps, motors, and bases were handled with the crawl beam, but the heavy discharge pipes which go to one side were out of range



DETAIL OF FOUNDATION FOR MAIN PUMPS

SCALE ½" = 1'

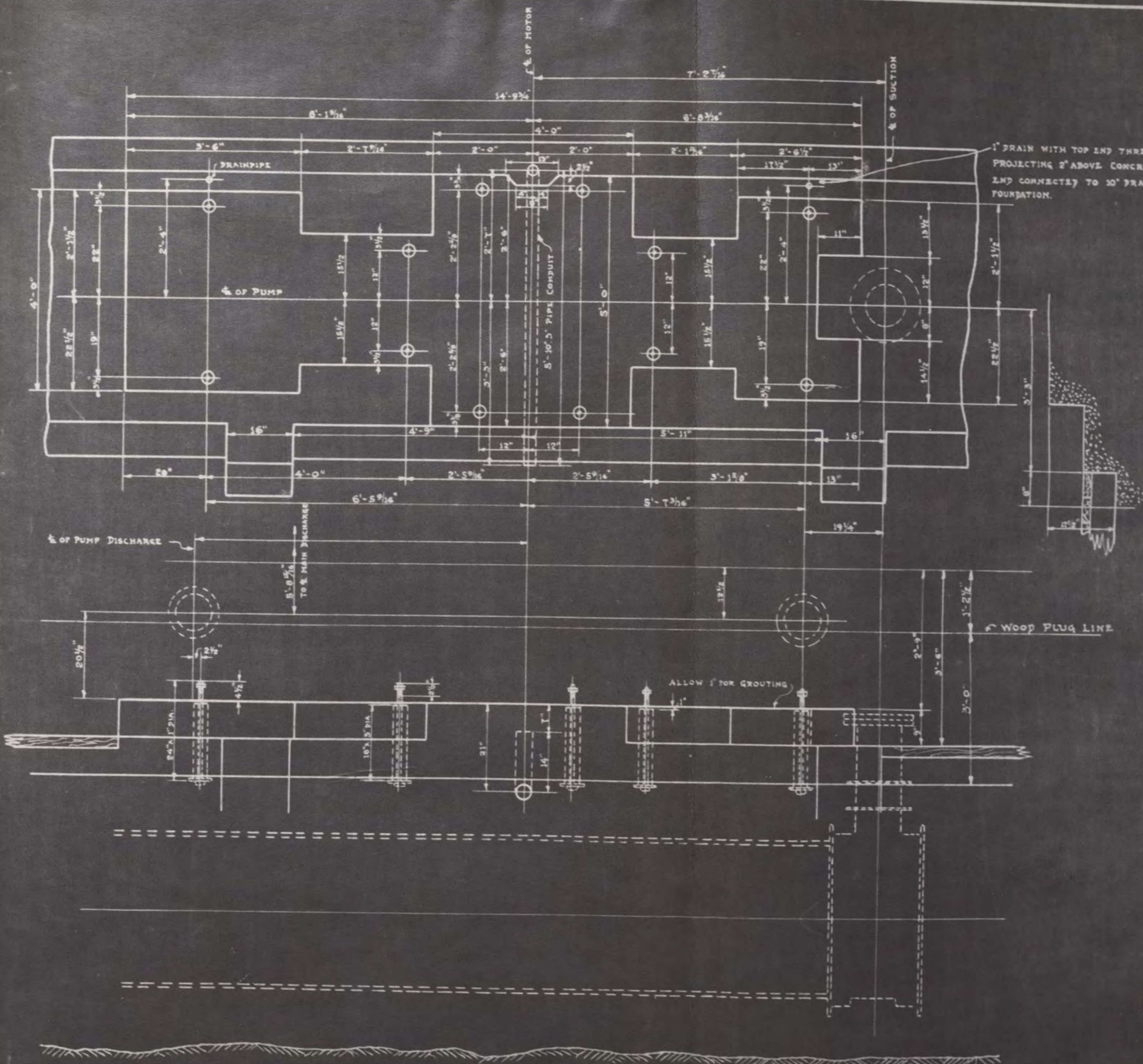
Plate #12



Details of Sump Pump Foundation
For Position see Plate #11

R.H.M.

Plate #13



DETAIL OF FOUNDATION FOR MAIN PUMPS

SCALE ½" = 1'

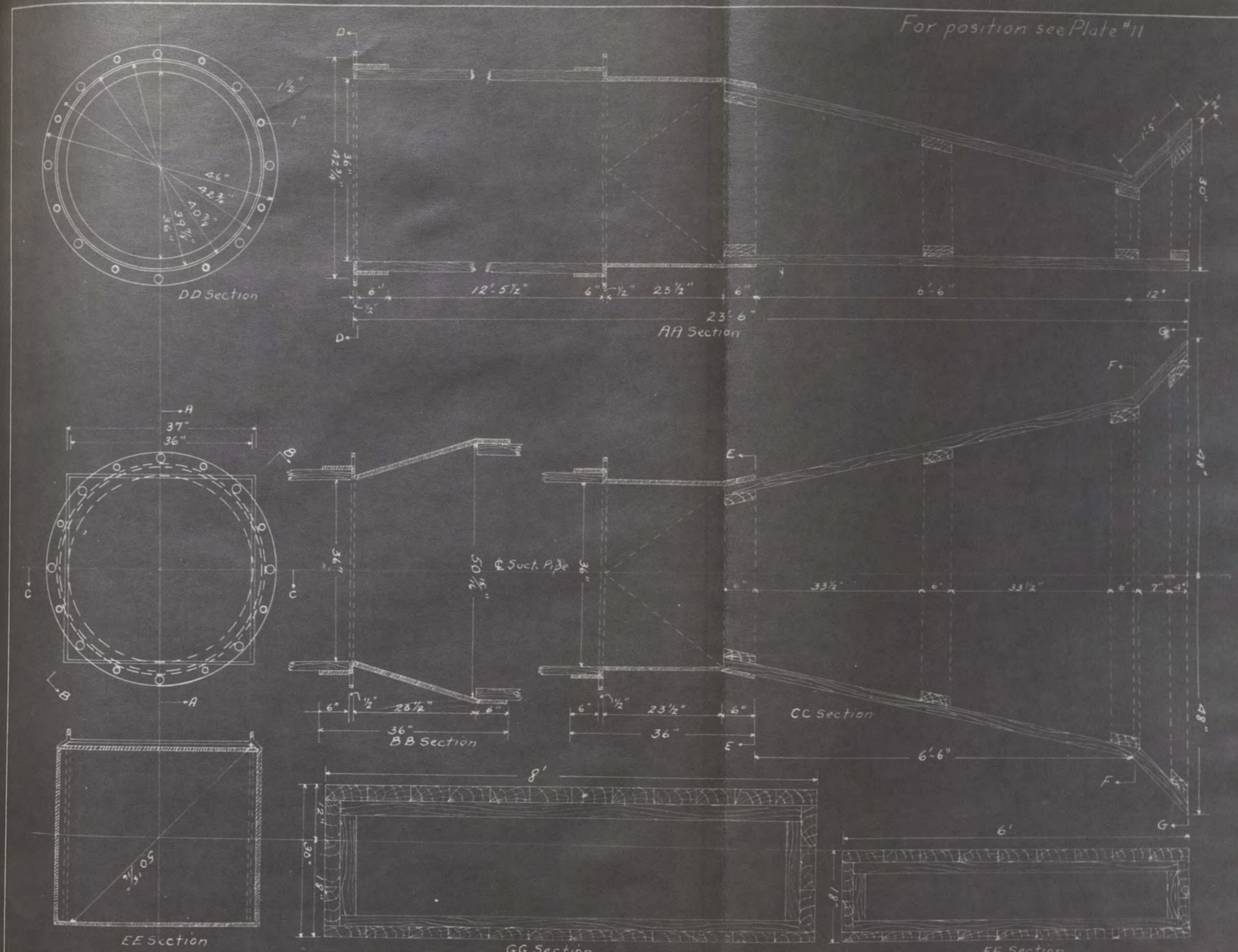
of the crawl beam and hadto be raised into place with the aid of jacks and staging. The pipes were supported with heavy steel posts and brackets. The bottom of each post fitted into a place provided for it in the concrete motor bases. The first pipe at the far end of the pump station was eight inches in diameter, and each section of pipe in the discharge line increased in size until the pipe which joined the elbow at the bottom of the water discharge raise was 30 in. in diameter. The first pipe in the discharge line has a capacity of 2500 gallons per minute, the second, 5000, and so on in this ratio until the seventh pipe is capable of handling 17,500 gallons of water per minute, or the combined capacities of all the pumps. Each pump has an in-- take and a discharge valve so that they can be operated singly or collectively, according to the need. The pumps were installed and adjusted by the mechanical department in two months time. At the same time the electrical department installed the starter boxes, transformers, and lighting fixtures.

CONCRETE BULKHEADS

There were four reinforced concrete protective bulkheads to be built. The three with doors were located on the 2900, 3100 and 3300 levels, and the one with the control valves was located on the 3300 level.

The excavations for the two concrete bulkheads on the 3300 level were commenced. (See Plate #11 for position) The one in the main transportation crosscut was to be equipped with a safety door capable of resisting 250 lbs. pressure per sq. in. This door could be closed in case of an emergency to prevent the water from flooding the pump room or the shaft. The door and frame were made of cast steel, and their combined weight was about three tons. The other bulkhead, located in the crosscut from the screen chamber to the vein was for the control valves. It carried the 30 in. drainage water pipe, the 6 in. high pressure air line, the 23 in. ventilation pipe, and a 20 in. manhole pipe. All of these pipes were equipped with high pressure control valves. It was necessary to construct the two bulkheads on the 3300 level before we could proceed with the development planned for this level, or start the 5400 ft. crosscut to the Aguas Calientes mine due to the danger from encountering an unexpected flow of water.

We were limited somewhat in our choice of a site for the bulkhead with the safety door. It had to be located in the main transportation crosscut somewhere between the vein and the cross cut to the screen chamber. This limited us to about 150 ft. Much of the ground was too blocky to be suitable, and other sections were too wet, which cut our actual limits to within 50 ft. We chose the blocky ground rather than the wet, because



Union Between Screen Chamber and Suction Pipe

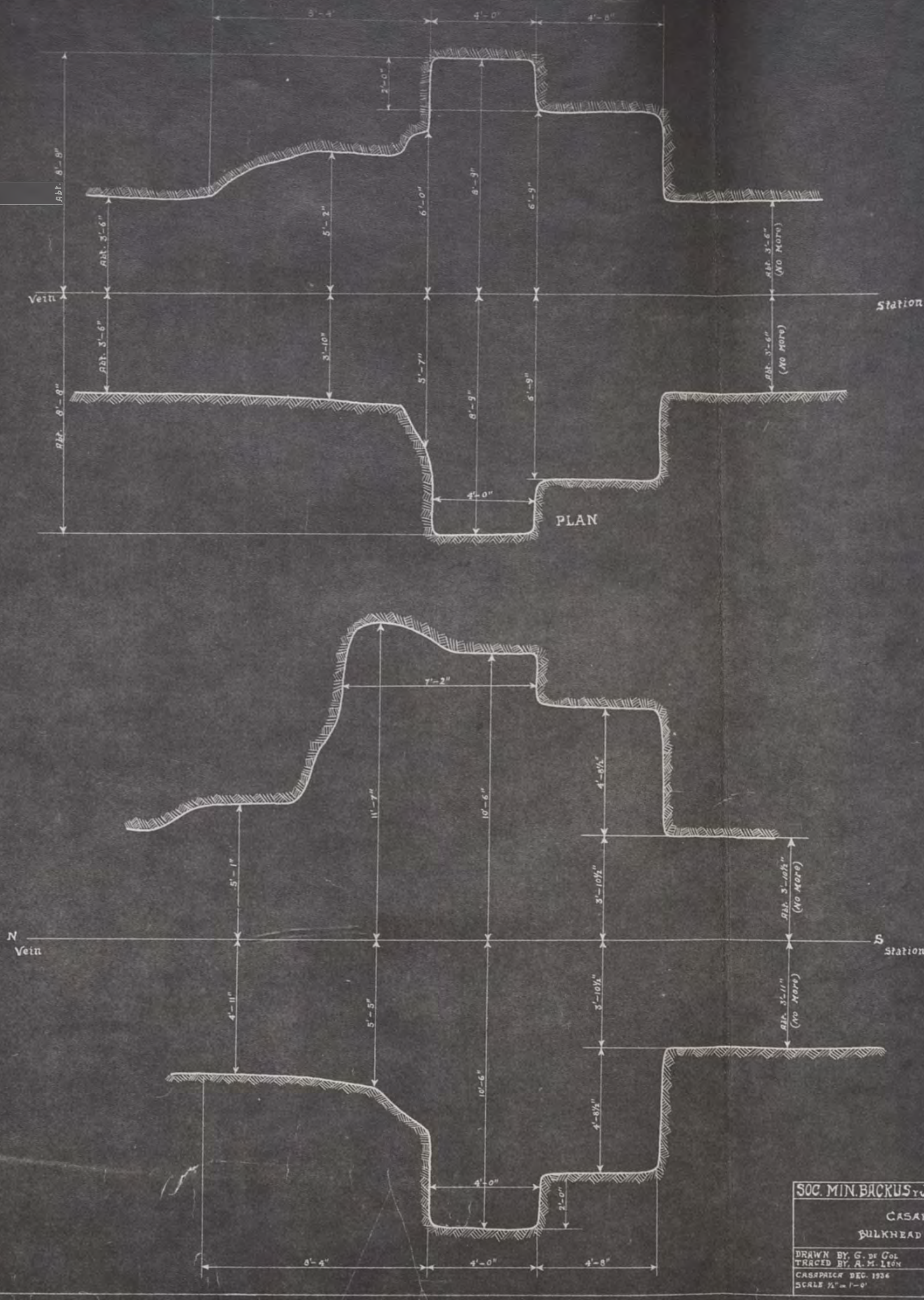
R.H.M.

Plate #10

the former offered less difficulties for pouring concrete. With the site chosen, we started the excavation. (See Plate 7-G-30 for details of excavation) The floor, back, and sides were cut out with shoulders left in the excavation to provide a better means of anchoring the bulkhead. Unfortunately, the last blast made in the back of the excavation cut a small flow of water. Although the flow amounted to only 40 gallons per minute, it would have been sufficient to wash all the cement from the concrete if it were not diverted in some manner. The water was finally diverted by inserting a four inch pipe in the fissure and cementing around it.

Hanging the steel door frame in place was difficult due to the limited space and the lack of facilities. Three 10 in. by 10 in. stulls were blocked in place across the top of the excavation from which to hang the chain blocks used to hold the frame in position while the concretewas being poured around it. All the reinforcing iron was placed in position and we were ready to pour the concrete.

While the forms for the bulkhead were being built, the mechanics dismantled the concrete mixer used in the pump station, brought it up and assembled it on the 3300 level close to the site of the bulkhead. The concrete for the bulkhead was poured in nine, eight-hour shifts. It was a nonolithic pour using a 1-1½-3 mix. However, the job was considerably more difficult than it appears due to the manner in which we had to work. The concrete was brought from the mixer to the bulkhead in wheelbarrows, dumped onto a steel sheet, and shoveled by hand into the form. So long as the concrete could be shoveled



SOC. MIN. BACKUS Y JOHNSTON DEL PERU

CASAPALCA

BULKHEAD WITH DOOR

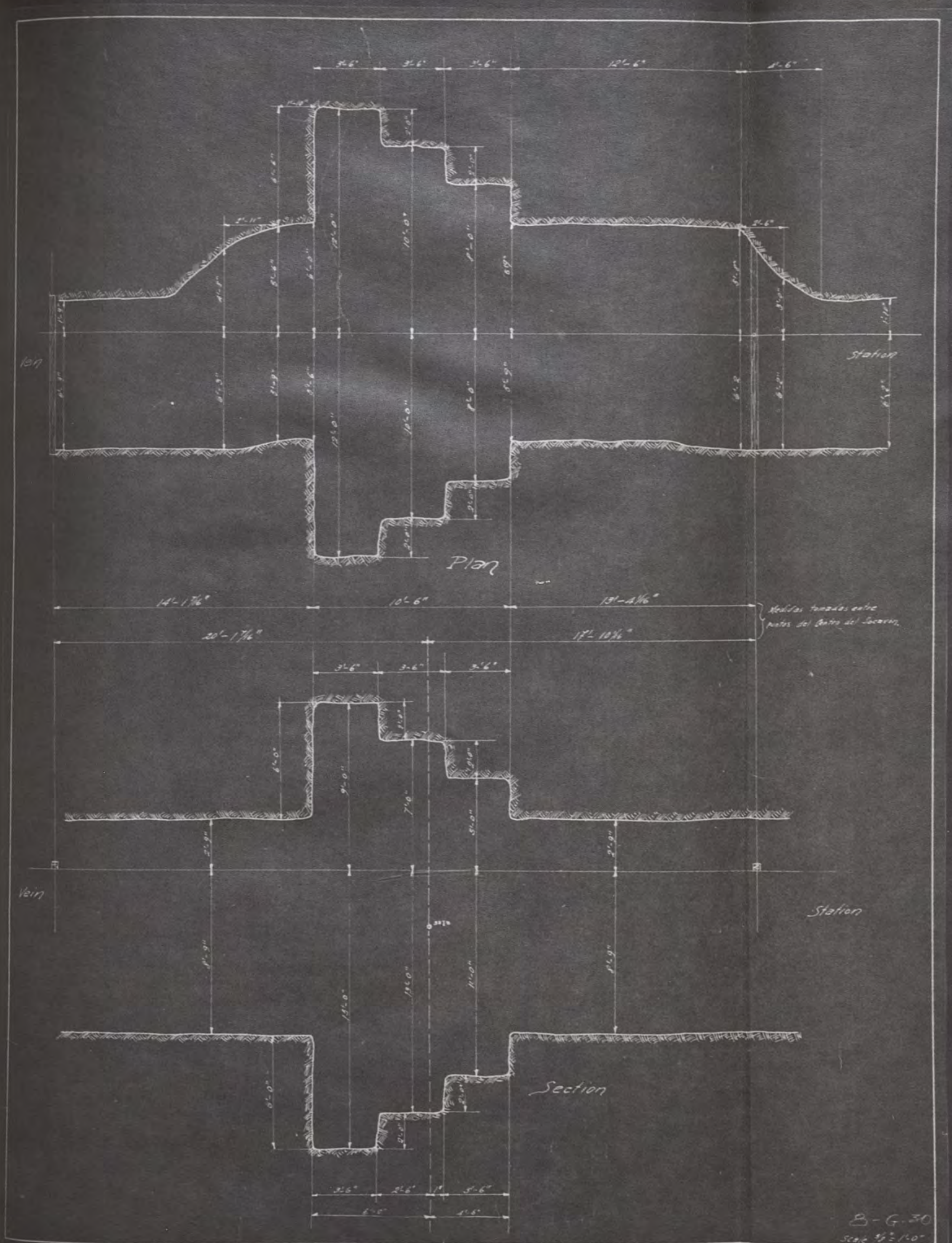
DRAWN BY. G. DE GOL — CHECKED BY.
TRACED BY. A. M. LEÓN — APROVED BY.

CASAPALCA DEC. 1936
SCALE ½" = 1'-0'

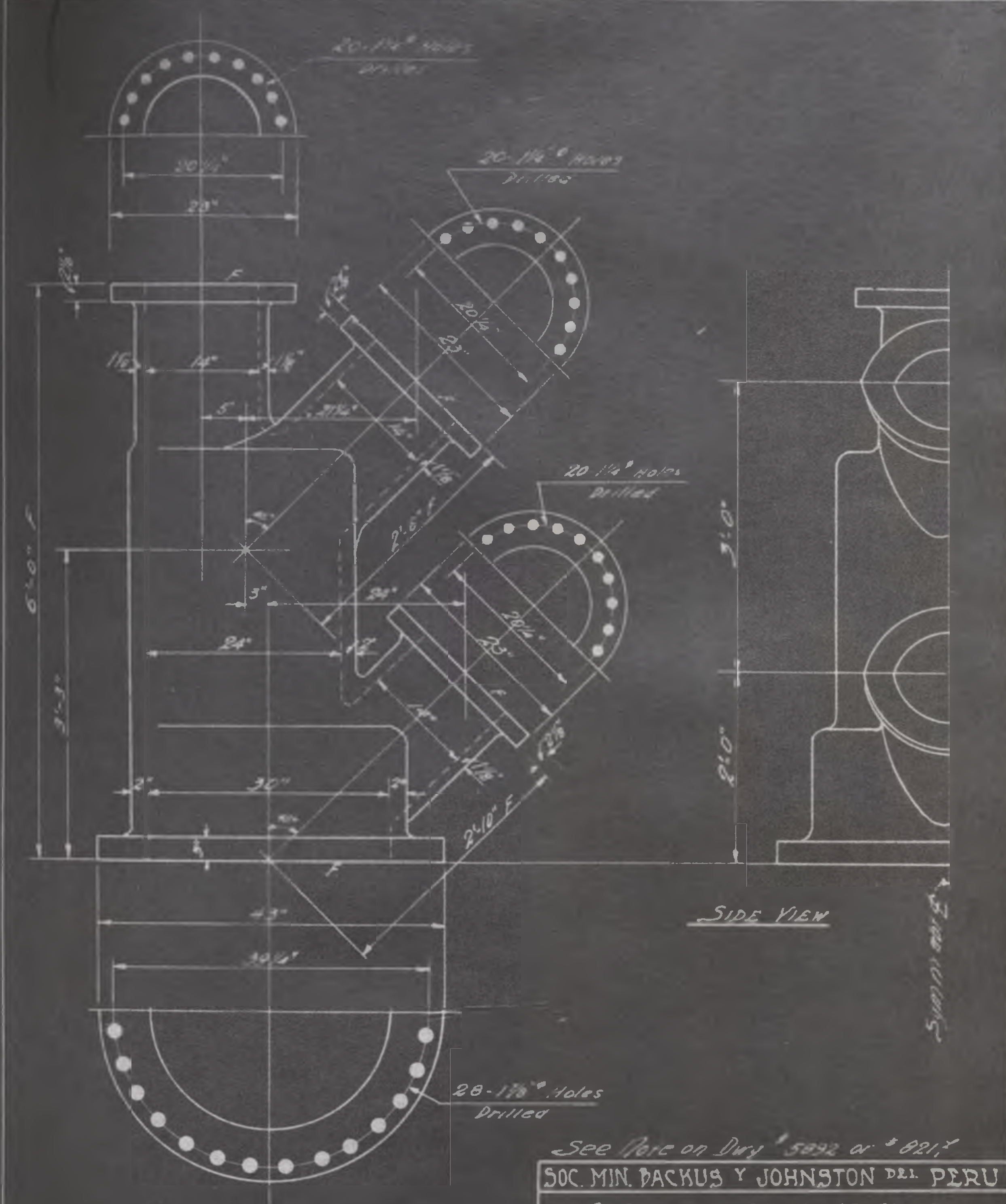
7-G-30

directly into the form, the work progressed rapidly, but after the form had been filled to a height of four feet above the track level the concrete had to be loaded into cans and hoisted with a block and tackle to a point where it could be poured into the form. The speed of pouring slowed down as the level of the concrete neared the top of the form. We had started tamping the concrete with air driven back-fill tampers, but found it was more convient to do the job by hand. The back-fill tampers were too long and there was too much reinforcing iron inside the form, which restricted their use. The men working inside the form tamping the concrete had to be relieved frequently because of the heat generated by the concrete after it had commenced to set. In spite of the primitive methods employed, the bulkhead was finished in good time.

The excavation for the bulkhead with valves offered no difficulties, because the rock was hard, free of fissures, and dry. (See Plate #8-G-30) The form for this job was much easier to build than the one for the bulkhead with the escape door, because the large pipes were laid horizontally and could be supported partly by the form, and partly by steel horses placed in the center of the form under each pipe. The three gate valves on the drainage water pipe, each 14 in. in diameter, were contained in a single bronze casting. (See Plate #13-H-30) The other pipes had one gate valve each. All the valves were designed to resist a pressure of 250 lbs. per sq. in. The same reinforcing design was used on this bulkhead as for the other. The concrete was poured monolithically in nine, eight hour shifts using a 1-1½-3 mix.



3'-6"
3'-6"
3'-6"
12'-6"
4'-6"
Vein
Station
Plan
14'-1 7/16"
10'-6"
13'-4 1/16"
Medidas tomadas entre puntos del Centro del Socavon.
20'-1 7/16"
17'-10 1/16"
3'-6"
3'-6"
3'-6"
Vein
Station
Section
3'-6"
2'-6"
1"
3'-6"
6'-0"
4'-6"
B-G-30
Scale 3/8" = 1'-0"



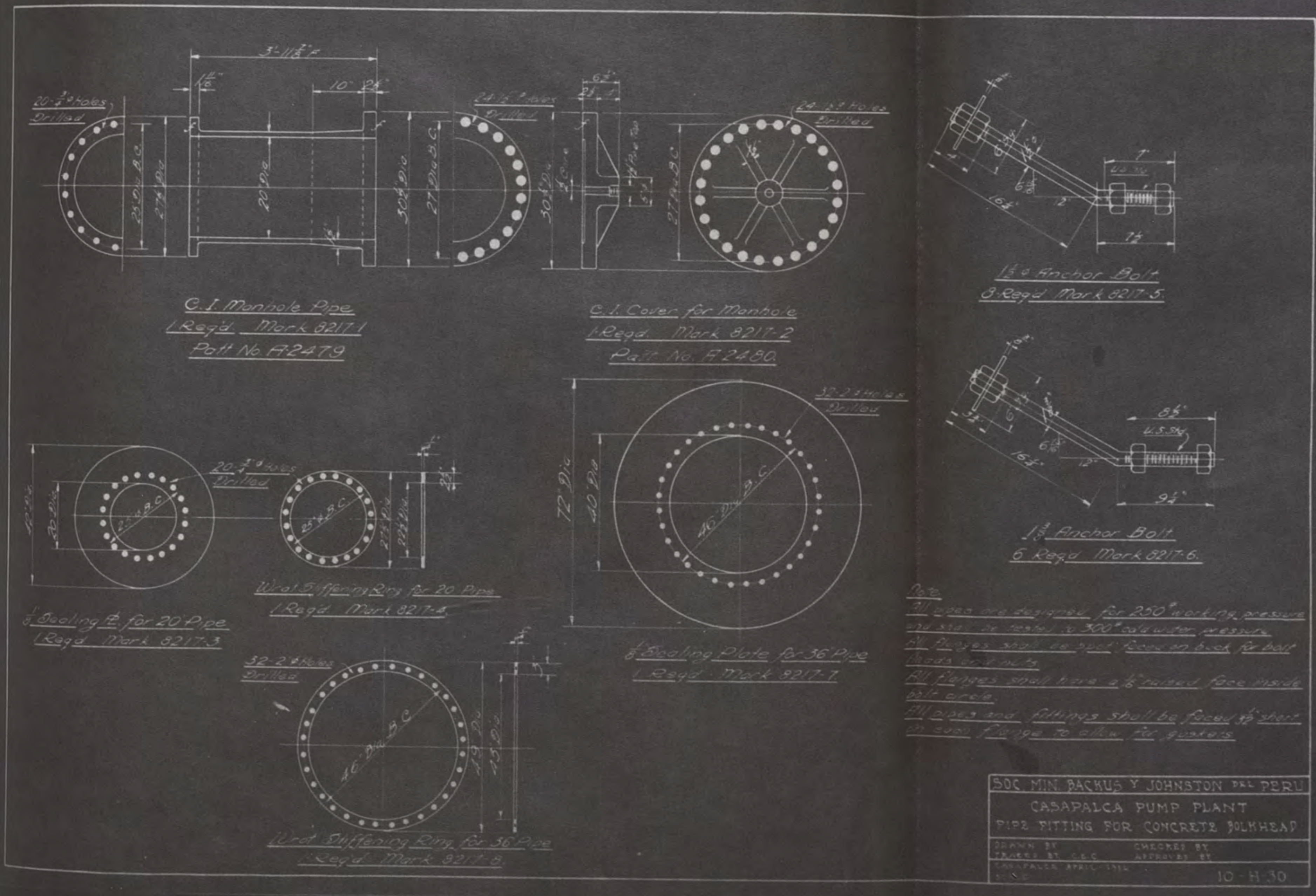
See Note on Dwg #5892 or #821.7

MAKE ONE - MARK 5874

CAST IRON DOUBLE LATERAL

PATT No. A. 2483

SOC. MIN. BACKUS Y JOHNSTON DEL PERU	
CASAPALCA PUMP STATION C.I. PIPE FOR CONC BULKHEAD	
DRAWN BY. H.J.C. TRACED BY C.E.C.	CHECKED BY APPROVED BY
CASAPALCA, APRIL 1936 SCALE: ¼" = 1'-0"	13-H-30

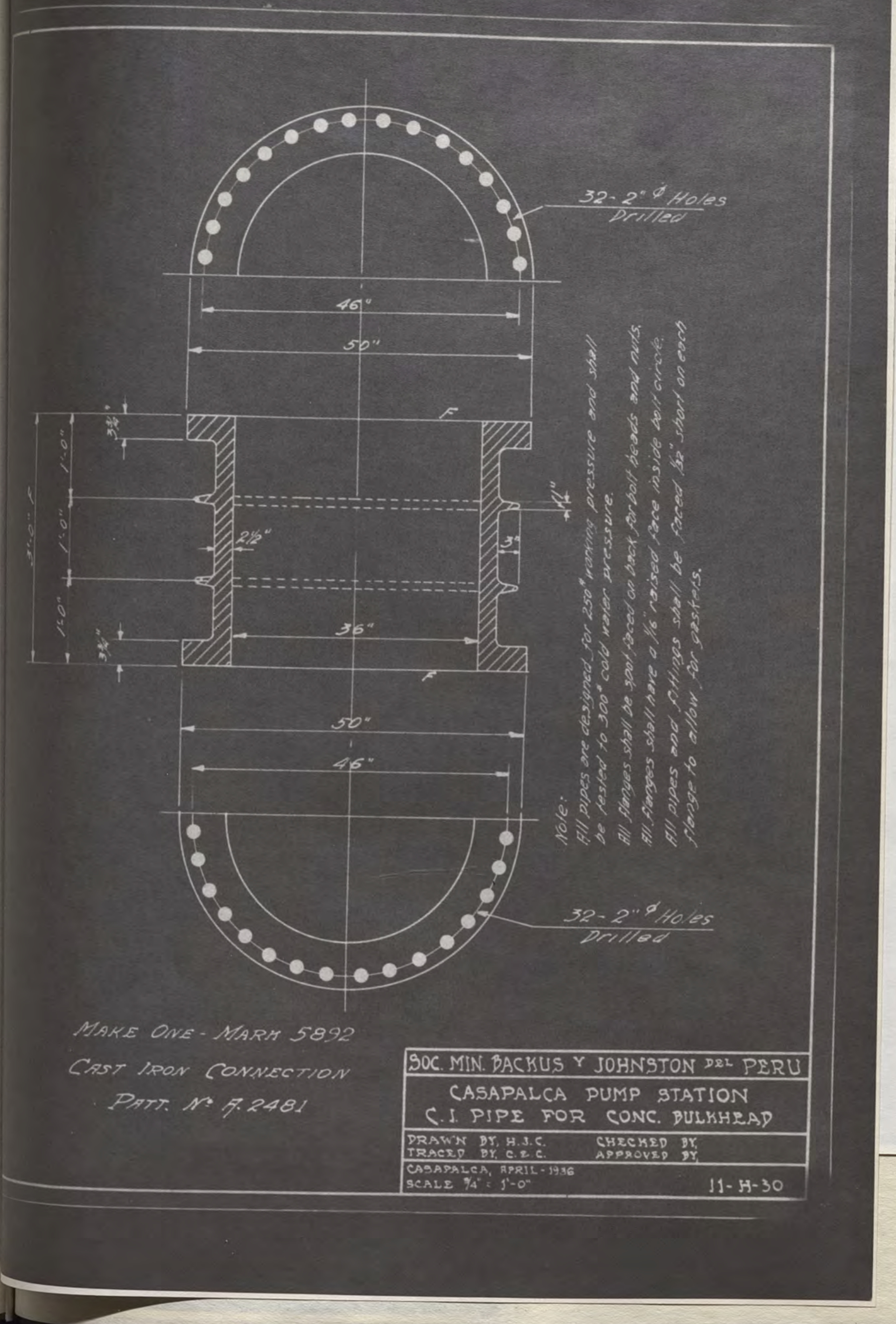

C.I. Manhole Pipe
1 Req'd Mark 8217-1
Patt No. A-2479
C.I. Cover for Manhole
1 Req'd Mark 8217-2
Patt No. A-2480.
1⅛ Anchor Bolt
8 Req'd Mark 8217-5.
1⅜ Anchor Bolt
6 Req'd Mark 8217-6.
Wrot Stiffening Ring for 20 Pipe
1 Req'd Mark 8217-4
Sealing Pl. for 20 Pipe
1 Req'd Mark 8217-3
Sealing Plate for 36 Pipe
1 Req'd Mark 8217-7
Wrot Stiffening Ring for 36 Pipe
1 Req'd Mark 8217-8
Note
All pipes are designed for 250# working pressure
All flanges shall have a raised face inside bolt circle.
All pipes and fittings shall be faced short on each flange to allow for gaskets
SOC. MIN. BACKUS Y JOHNSTON DEL PERU
CASAPALCA PUMP PLANT
PIPE FITTING FOR CONCRETE BULKHEAD
DRAWN BY
TRACED BY C.E.C.
CHECKED BY
APPROVED BY
10-H-30

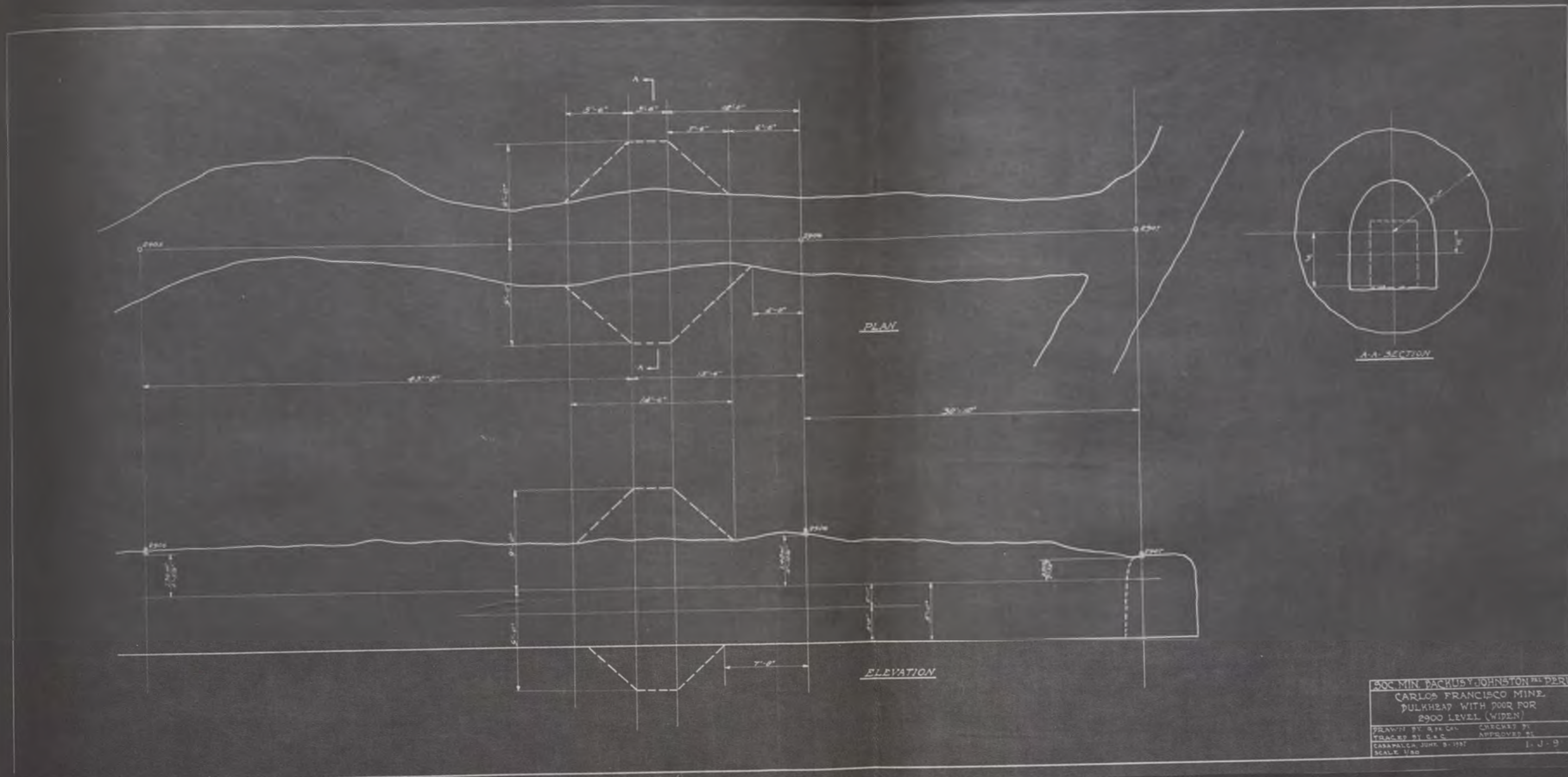
3100 level Bulkhead with Door

The 3100 and the 3300 bulkheads and escape doors are duplicates so no attempt will be made here to describe the work. The same problems were encountered, but with the experience of the other two bulkheads behind us, we had no difficulty with this one.

2900 level Bulkhead with Door

The bulkhead on the 2900 was a small one designed to resist a pressure of 75 lbs. per sq. in. The door, big enough to allow a mine car to pass, was made in our machine shop of 1/4 in. steel plate. It is best described as a hollow, regularly constructed trapezoid. The excavation was not as big as for the others due to the greatly reduced pressure it would have to resist. (See Plate #1-J-19) Barring a major shutdown in the powerhouse or pump station, it is very unlikely that this door will ever be used, because under normal conditions the water will require a week to flood the lower levels and reach this level. As the lower levels are extended this time element will increase in proportion. However, we had to guard against the one possibility and put a protective door on this level. Since this bulkhead was made after we had finished concreting the water discharge column, all the work connected with the disposal of mine water below the 2700 level had now been finished.


32-2" ϕ Holes Drilled
46"
50"
F
3'-0" F
1'-0"
1'-0"
1'-0"
3¾"
3¾"
2½"
3"
36"
F
50"
46"
32-2" ϕ Holes Drilled
Note:
All pipes are designed for 250# working pressure and shall be tested to 300# cold water pressure.
All flanges shall be spot faced on back for bolt heads and nuts.
All flanges shall have a 1/16" raised face inside bolt circle.
All pipes and fittings shall be faced 1/32" short on each flange to allow for gaskets.
MAKE ONE - MARK 5892
CAST IRON CONNECTION
PATT. Nº A.2481
SOC. MIN. BACKUS Y JOHNSTON DEL PERU
CASAPALCA PUMP STATION
C.I. PIPE FOR CONC. BULKHEAD
DRAWN BY, H.J.C.
TRACED BY, C.E.C.
CHECKED BY,
APPROVED BY,
CASAPALCA, APRIL - 1936
SCALE 3/4" = 1'-0"
11-H-30


PLAN
A-A SECTION
ELEVATION
SOC. MIN. BACKUS Y JOHNSTON DEL PERU
CARLOS FRANCISCO MINE
BULKHEAD WITH DOOR FOR
2900 LEVEL (WIDEN)
DRAWN BY
CHECKED BY
TRACED BY
APPROVED BY
SCALE 1/80
1-J-9

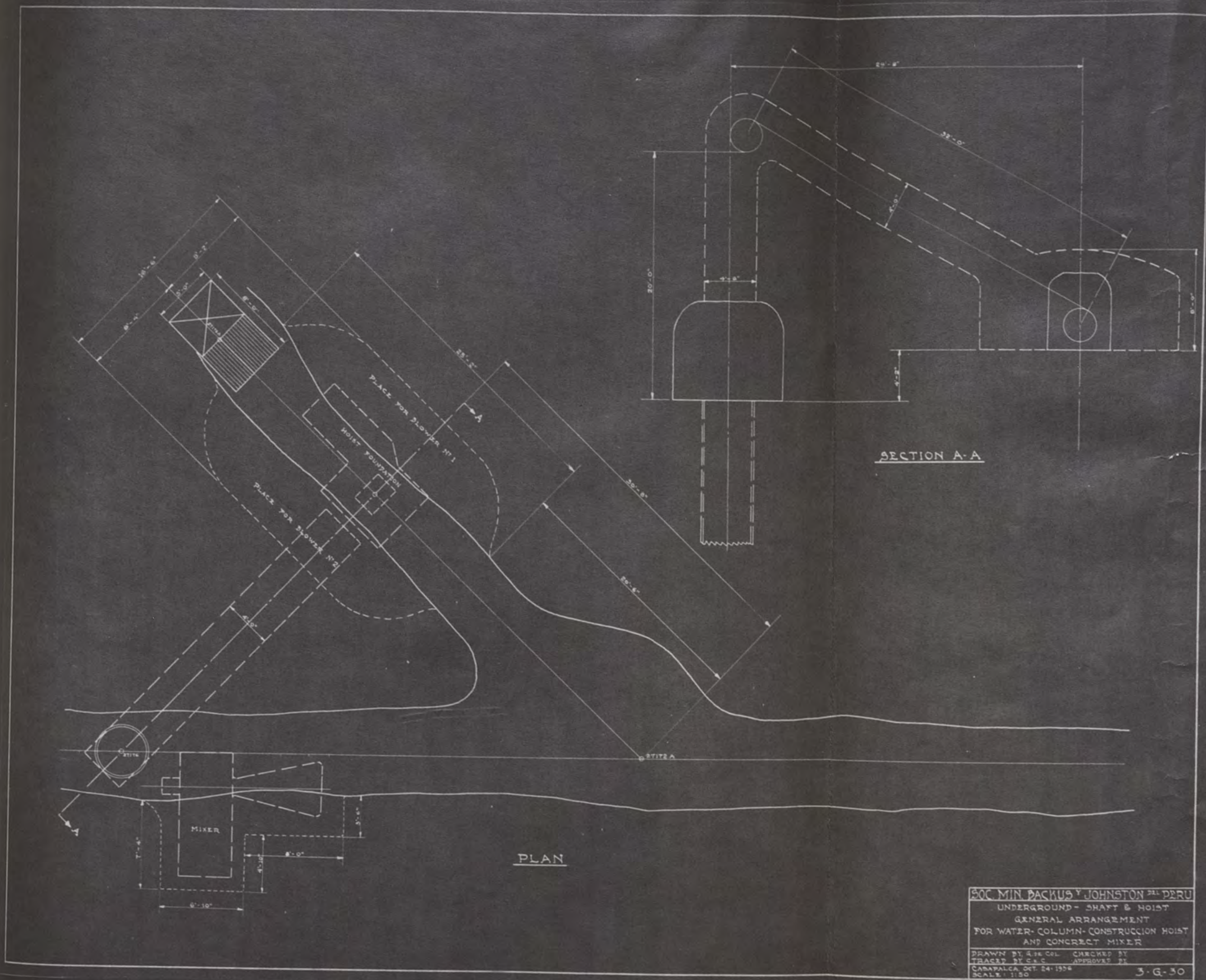
WATER DISCHARGE COLUMN

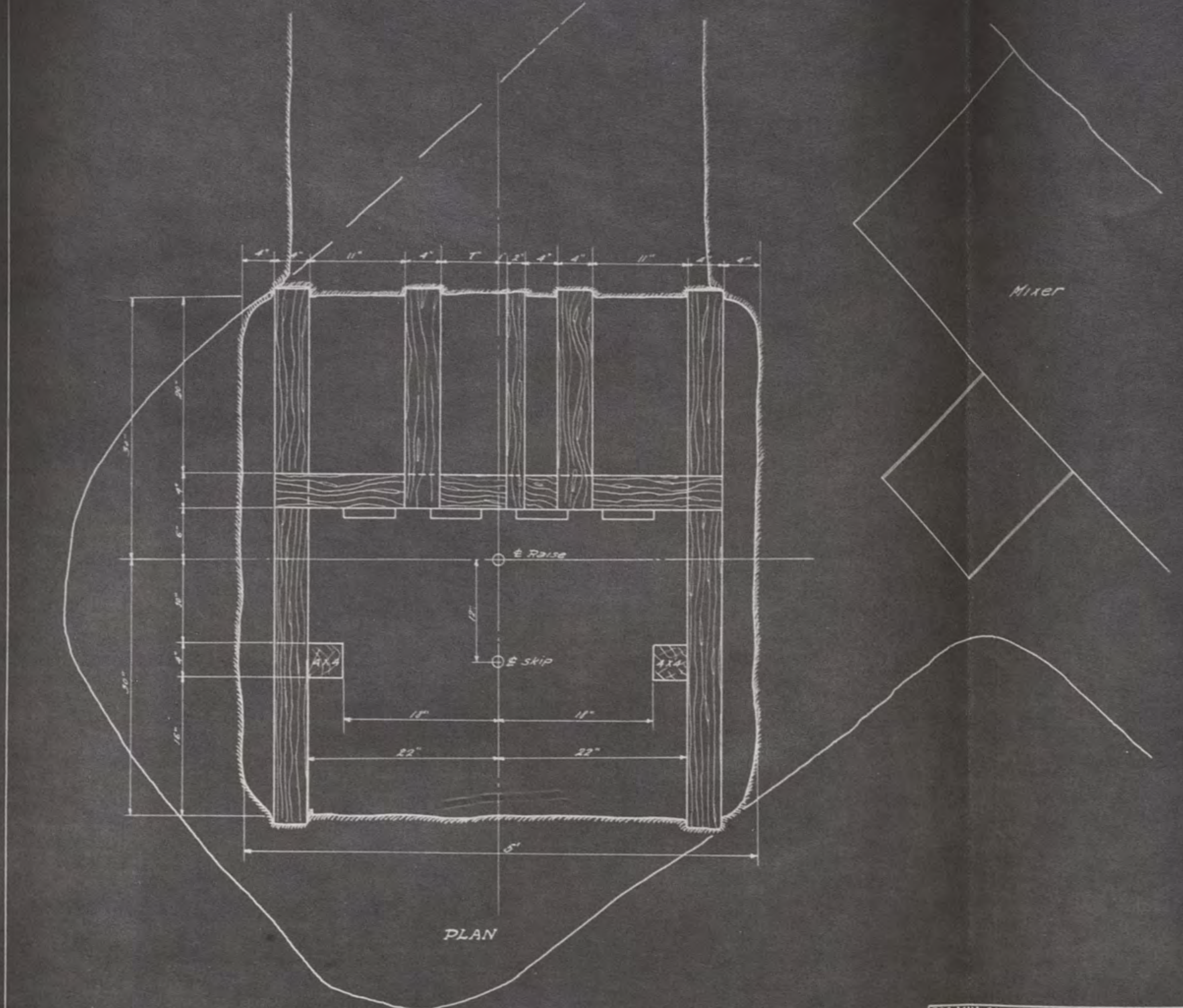
The water discharge and the ventilation raises having now been completed, it suited our schedule to concrete the water raise at this time in order to proceed with the development work planned for the 3300 level.

Several methods of placing the concrete in the raise were considered, but the one finally decided upon was to lower it in a bucket. A 3/4 yd. bucket was designed having a hinged bottom, and with shoes for operating as a skip. For a hoist room we could use the room cut out at the top of the ventilation raise in which we planned to install later three large blowers. By extending upward the water raise for another 15 ft. , and driving a flat raise from the ventilation room to connect with it, our hoisting problem was solved. (See Plates #3-E-30 and 3-G-30 for the concreting arrangement and position of the hoist)

The original water raise of $4\frac{1}{2}$ ft. by $4\frac{1}{2}$ ft. had been driven with a chute and manway, but this timber arrangement was not suitable to our plans for concreting the water column so it had to be taken out and replaced with the proper timber. (See Plate #2-G-12 for the new timber arrangement) Stripping the raise and putting in the new timber required several months time, but meanwhile we finished all the preliminary work.

After the water raise had been re-timbered, we put the two ribbed cast steel nipples in their positions at the bottom of the raise. Once they have been concreted in they form the bottom of the finished water raise. A heavy cast bronze elbow is bolted to the flange of the lowest nipple to make the connecting link between the pump station discharge line and


SECTION A-A
PLACE FOR BLOWER Nº 1
HOIST FOUNDATION
PLACE FOR BLOWER Nº 2
MIXER
PLAN
SOC. MIN. BACKUS Y JOHNSTON DEL PERU
UNDERGROUND - SHAFT & HOIST
GENERAL ARRANGEMENT
FOR WATER- COLUMN- CONSTRUCCION HOIST
AND CONCRECT MIXER
DRAWN BY G. DE COL. CHECKED BY
TRACED BY C. & C. APPROVED BY
CASAPALCA, OCT. 24-1936
SCALE: 1:50
3-G-30



SOC. MIN. BACKUS Y JOHNSTON DEL PERU

3314 - 2700 WATER COLUMN RAISE
TIMBER - ARRANGEMENT

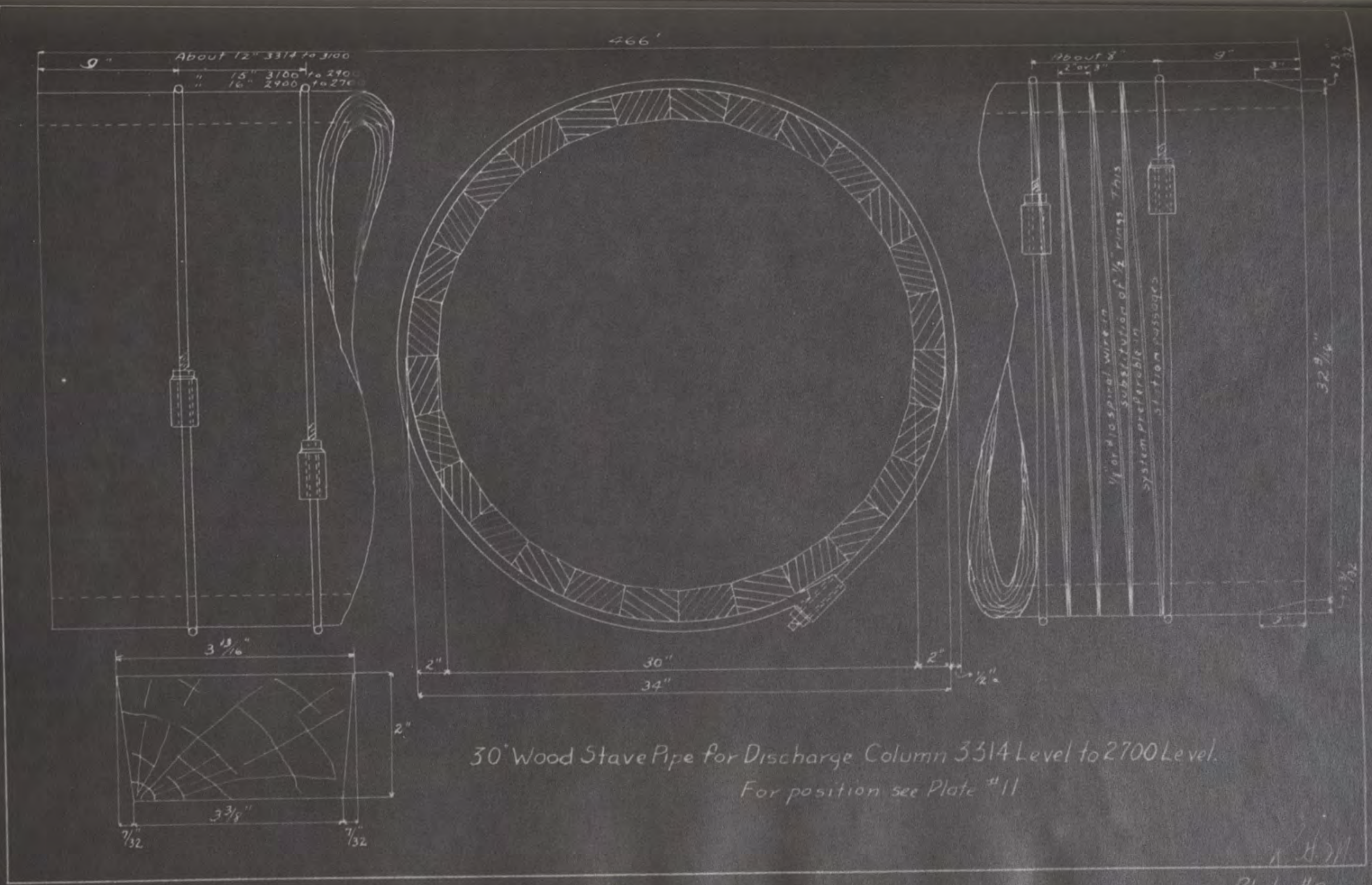
2-G-12

the water column. (See Plate #11 for position of nipples and elbow)

The job of concreting the nipple in place was of no consequence; the real job commenced with the first section of the wood stave pipe. Each 10 ft. section of pipe was assembled in the raise as needed. The 28 staves and the necessary number of pipe straps were lowered in the bucket, and as soon as the pipe had been put together, the reinforcing iron was sent down to be put in place. When this had been done, we concreted the 10 ft. section, and were ready to start on the next section.

Although all of the sections of the pipe were 10 ft. in length, the first one that was placed in the raise was made of 9 and 10 ft. staves. This gave a toothed appearance to the top of the first section of pipe. By making the rest of the pipe with 10 ft. staves, this effect was gained in each section of pipe. In this manner each section of pipe was dove-tailed to the next which made a better joint than if we had used a straight joint. The average time required to assemble a length of pipe and to put in all the reinforcing was about $1\frac{1}{2}$ hours. If, however, through unforseen circumstances the section of pipe could not be prepared in that time, we sent down several buckets of freshly mixed concrete to mix with that already poured in order to keep the pour monolithic. The entire column was poured in 84 eight hour shifts.

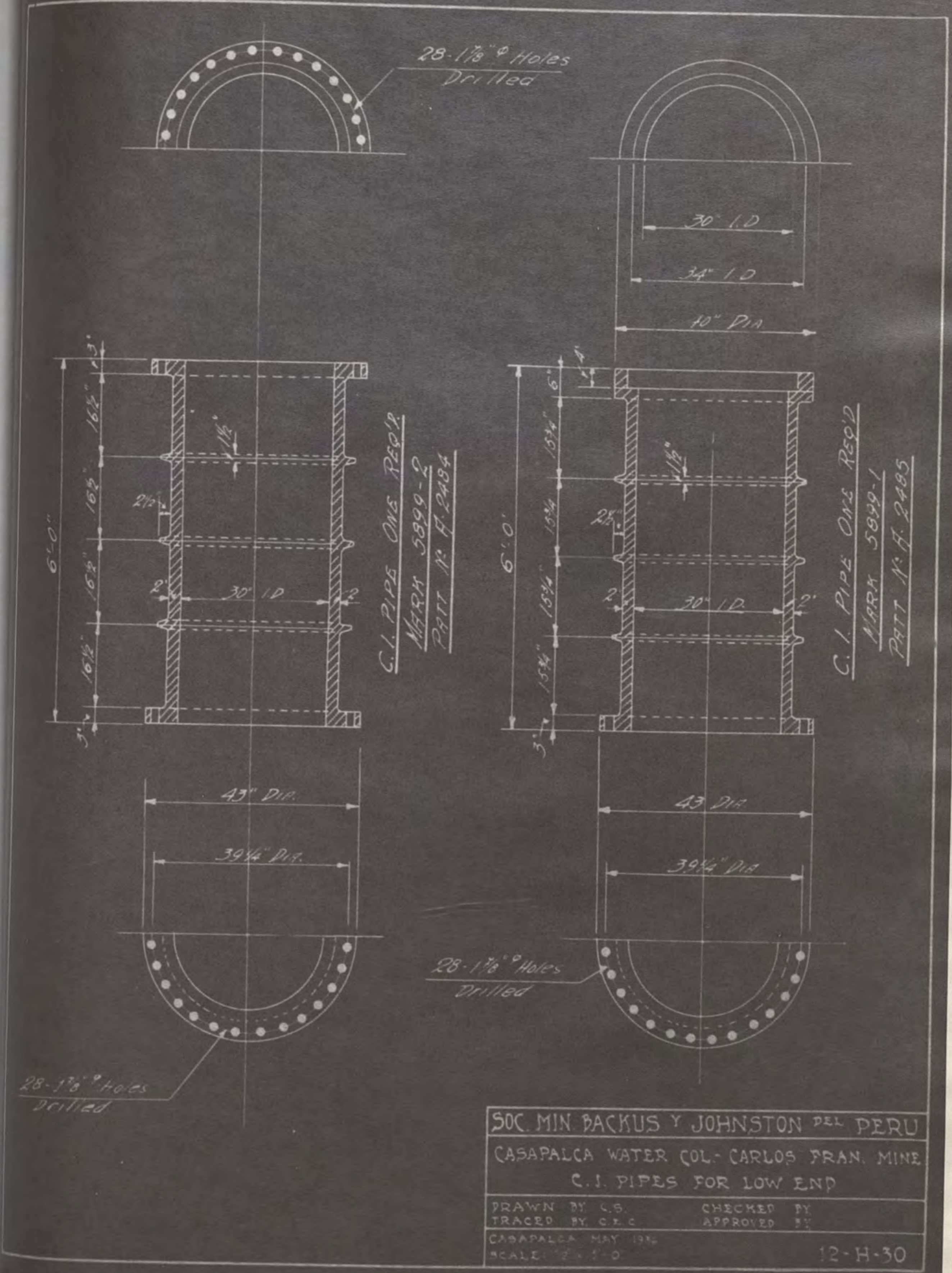
The only break in the routine came when we passed the 2900 and 3100 levels. On each of these levels a crosscut had been driven from the shaft station to the water column. This had been done when we drove the raise so that it could be driven



30" Wood Stave Pipe for Discharge Column 3314 Level to 2700 Level.

For position see Plate #11

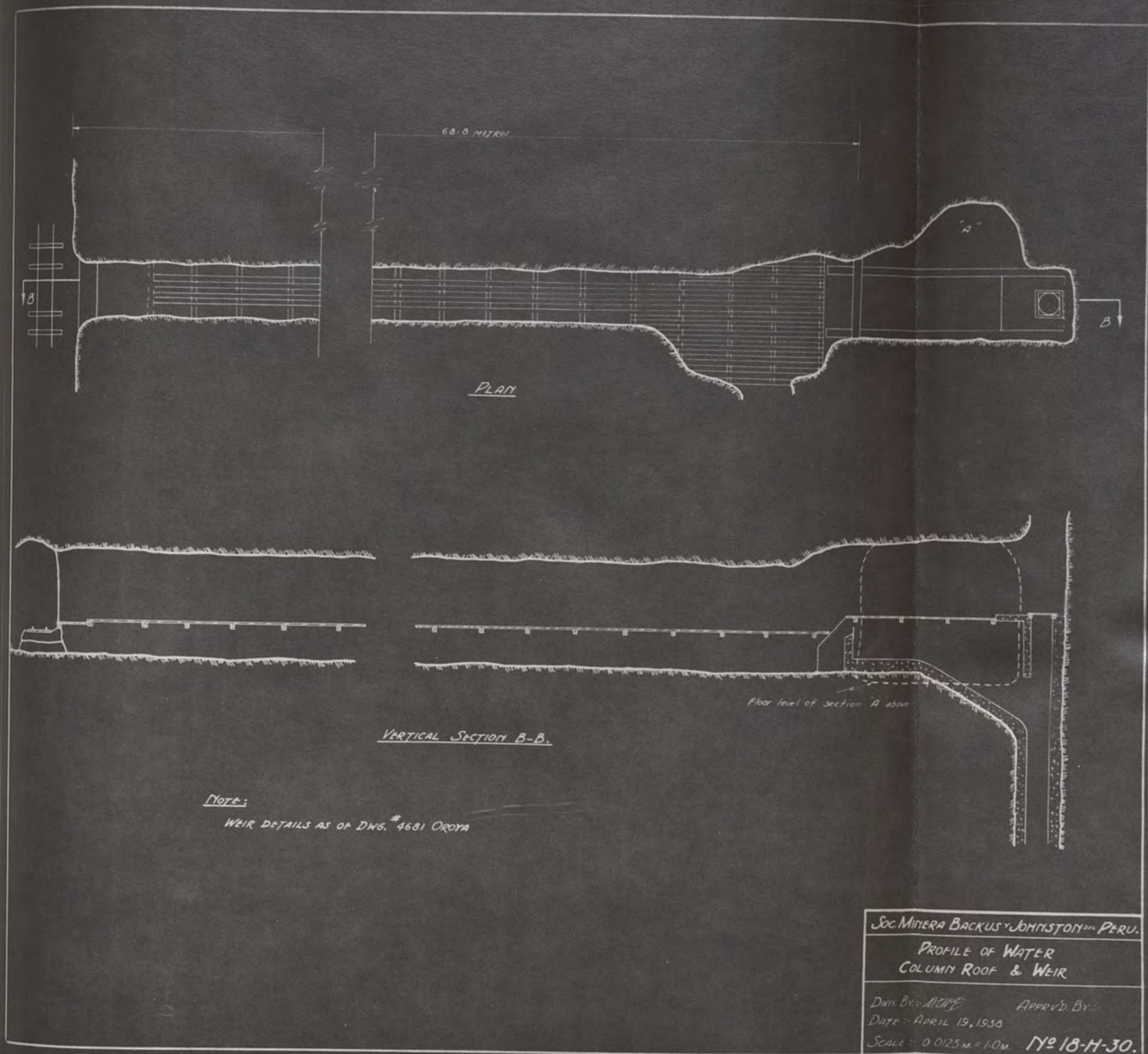
Plate #9


28-1⅞" ⌀ Holes Drilled
30" I.D.
34" I.D.
40" DIA
43" DIA.
39¼" DIA.
6'-0"
C.I. PIPE ONE REQ'D
MARK 5899-2
PATT No F 2484
C.I. PIPE ONE REQ'D
MARK 5899-1
PATT No F 2485
SOC. MIN. BACKUS Y JOHNSTON DEL PERU
CASAPALCA WATER COL.- CARLOS FRAN. MINE
C.I. PIPES FOR LOW END
DRAWN BY C.S.
TRACED BY C.E.C.
CHECKED BY
APPROVED BY
CASAPALCA MAY
SCALE:
12-H-30

from three faces simultaneously. However, this left the water column open on one side, and to prevent a failure in the concrete we had to strengthen the column considerably at these points. This was taken care of by increasing the amount of reinforcing used, and by increasing the thickness of the concrete around the wood stave pipe at this side. We increased the thickness of the concrete by building the forms several feet back from the raise in the crosscut. (See Plate #11 for this detail). Before pouring the concrete, we made provisions to secure our future supply of drilling water from the water column.

WEIR

The last job on the water column was the weir. Preparing and concreting it required two weeks time. Then a bridge or high line was constructed over the water crosscut that connects the water column to the main 2700 level drainage ditch. (See Plate #18-H-30).

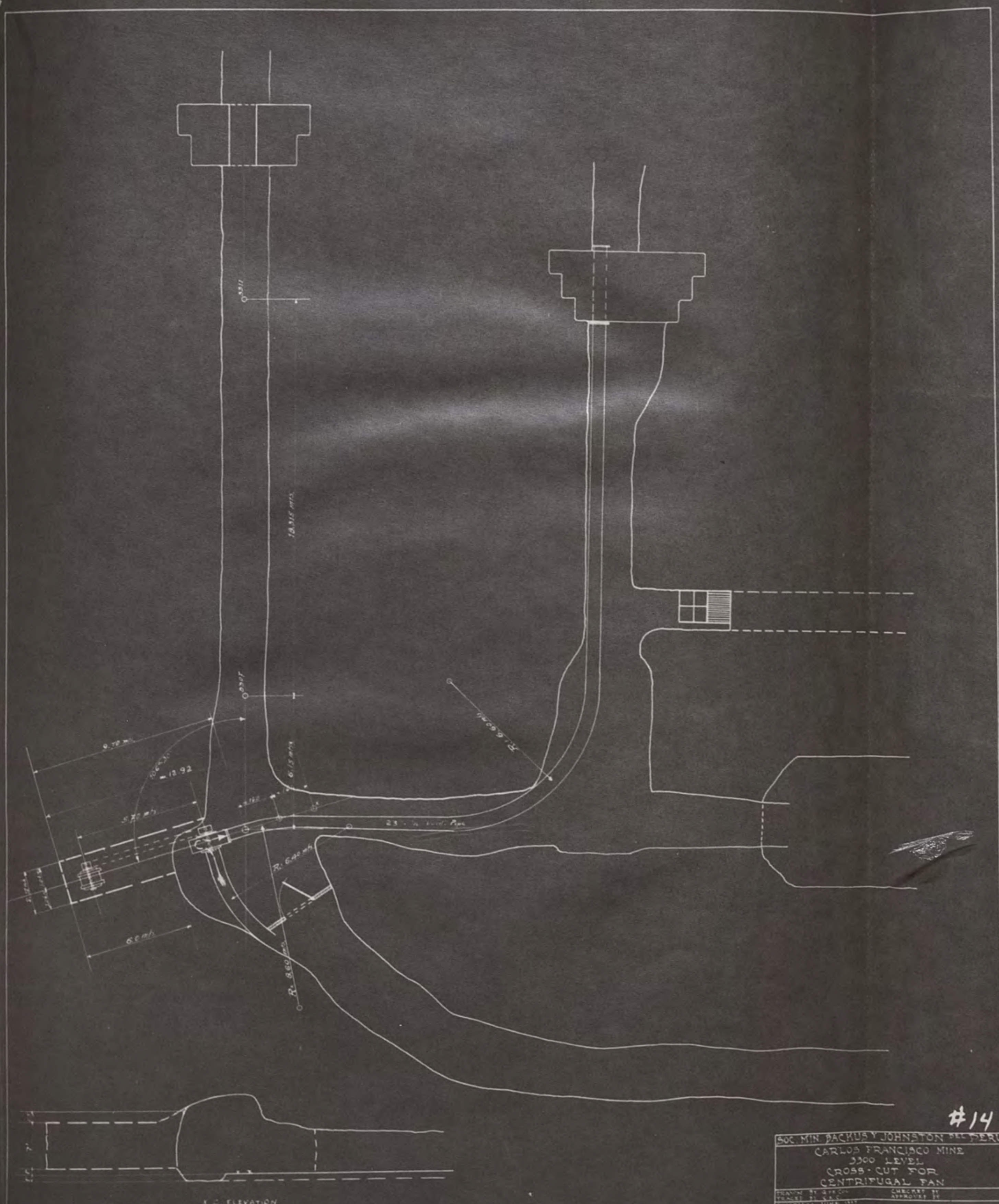

68.8 METROS
"A"
B
B
PLAN
Floor level of section "A" above
VERTICAL SECTION B-B.
NOTE:
WEIR DETAILS AS OF DWG. # 4681 OROYA
SOC. MINERA BACKUS Y JOHNSTON DEL PERU.
PROFILE OF WATER
COLUMN ROOF & WEIR
DWN. BY:-
APPRV'D. BY:-
DATE:- APRIL 19, 1938
SCALE = 0.0125 M. = 1.0 M.
Nº 18-H-30.

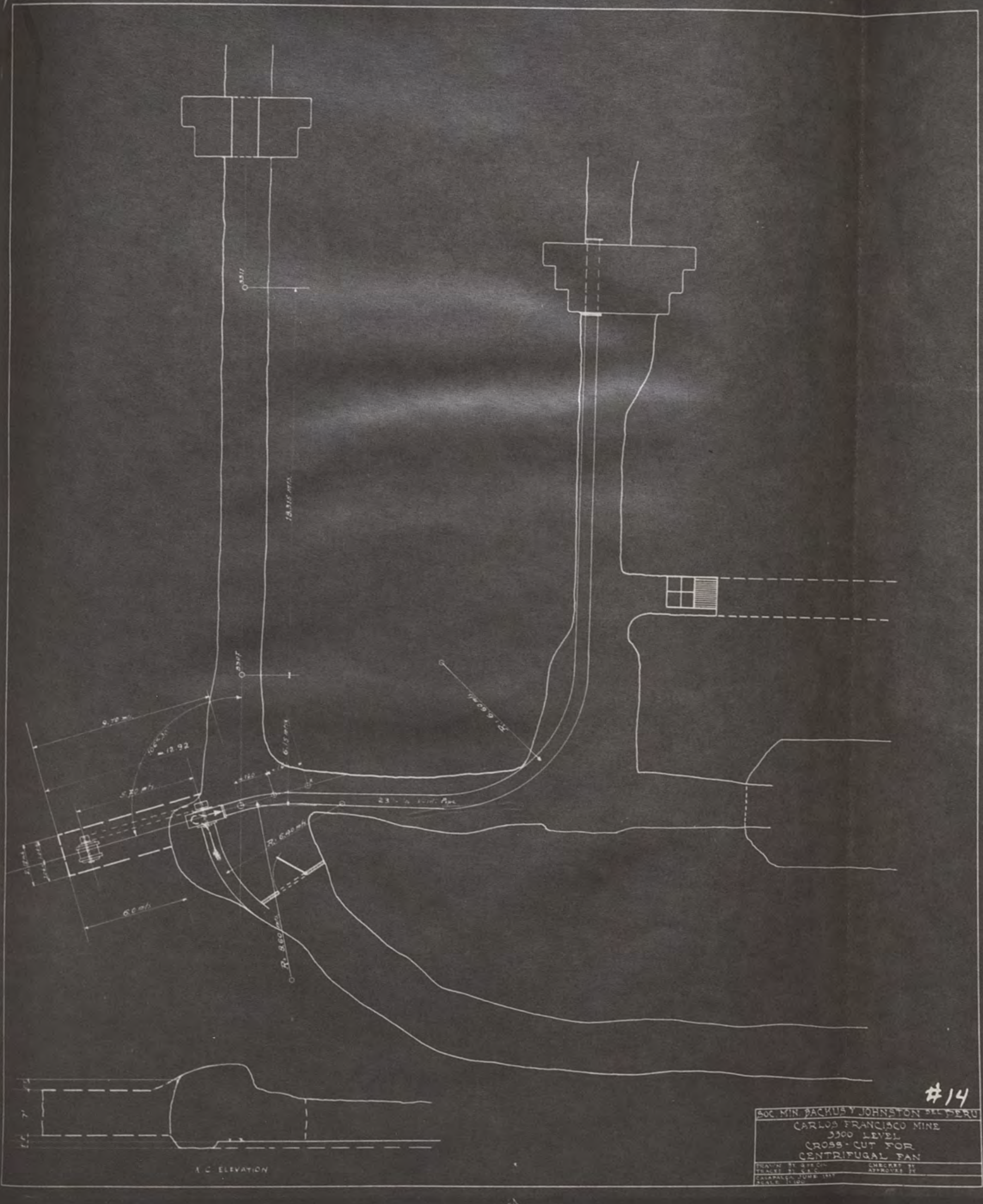
VENTILATION

Before the 5400 ft. crosscut to the Aguas Calientes mine could be started, we first had to provide adequate ventilation for the pump station. The water that would be encountered in this crosscut was hot, and since it would be flowing continuously through the pump station it would soon raise the air temperature to a point where the pump motors might burn out. Adequate ventilation for the pump station therefore, was of prime importance.

Previous to sinking the shaft below the 2700 level, the mine had been cool, and naturally ventilated, downcast through the stopes and the Carlos Francisco shaft. Now, the ventilation was down cast through the stopes and upcast through the shaft. This was an undesirable condition, because the warm moist air from the lower levels on passing through the cooler section of the shaft above the 2700 level caused a heavy fog. Within a short time the entire shaft was wet and dripping from the condensed moisture.

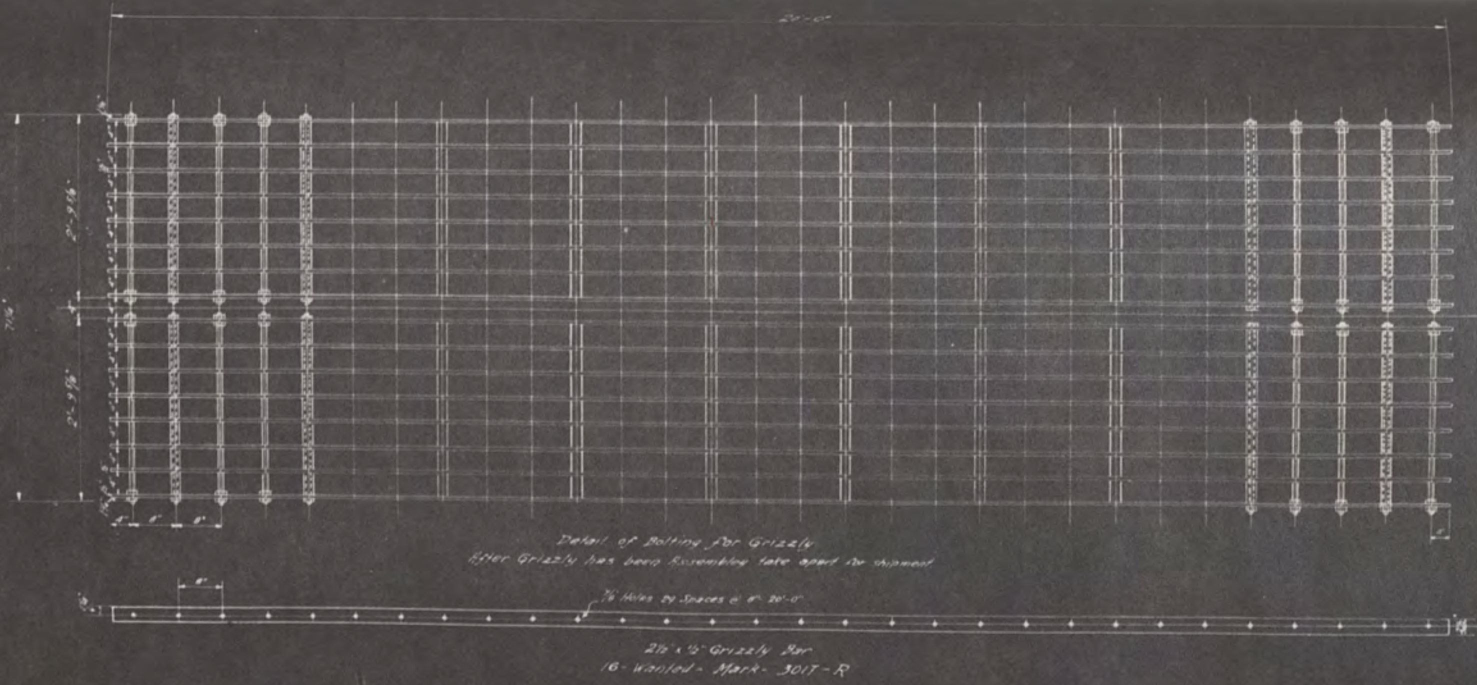
The Carlos Francisco shaft offered the closest and most abundant source of cool air for ventilating the pump room if we could reverse the air currents. We realized that it would have to be done mechanically, and for that reason had cut out the room at the top of the ventilation raise. We hoped that by installing three blowers here enough air would be drawn from the ventilation raise to create a reverse draft in the shaft. This would solve our problem because the air from the shaft had to pass through the pump station before it could reach the ventilation raise. The air drawn through the ventilation raise would be discharged into the main 2700 level haulage crosscut

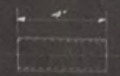

13.92
X C ELEVATION
#14
SOC. MIN. BACKUS Y JOHNSTON DEL PERU
CARLOS FRANCISCO MINE
3300 LEVEL
CROSS - CUT FOR
CENTRIFUGAL FAN



X C ELEVATION
#14
SOC. MIN. BACKUS Y JOHNSTON DEL PERU
CARLOS FRANCISCO MINE
3300 LEVEL
CROSS-CUT FOR
CENTRIFUGAL FAN

via the drainage crosscut, and finally pass out of the mine through the Bellavista Tunnel. However, this part of our plan miscarried. The blowers did not have sufficient force to overcome the back-pressure encountered in the Bellavista Tunnel. The distance from the ventilation raise to the surface by way of the Bellavista Tunnel is roughly 15,000 ft. , of which 10,000 ft. is timbered. We not only had overlooked the distance that the air had to travel, but had failed to consider the resistanee to the air set up by the timber, so we had to make some improvements in the original plans. Fortunately, at the company smelter in La Oroya we found an immense blower, which was brought to Casapalca and installed at the mouth of the Bellavista Tunnel. Although it had a rated capacity to deliver 250,000 cu. ft. of low pressure air per minute, 50,000 cu. ft. per minute was the best it could do drawing air from the Bellavista Tunnel. At any rate it solved our problem, and we succeeded in reversing the air currents in the Carlos Francisco shaft.





Nº REQ	A	B	MARK	REMARKS
40	2'-11 1/4"	3 1/4"	3017-S	DOUBLE NUTS
20	2'-11 1/4"	2"	3017-T	SINGLE

SOC MIN BACKUS Y JOHNSTON DEL PERU

TRASH RACKS - 3300 LEVEL

DRAWN BY — CHECKED BY
TRACED BY — APPROVED BY

REHABILITATION OF THE CARLOS FRANCISCO SHAFT

The final job of the development program as outlined for the Carlos Francisco mine was the installation of a new hoist, and the rehabilitation of the Carlos Francisco shaft to accomodate the 3½ ton skips. To accomplish this we had to move all the shaft dividers, double up the footwall sills from the 1700 level to the bottom of the shaft, move back the faces of the 2100 and the 2700 ore pockets, and completely renovate the 1900 level shaft station where we change over the skips and man cages. The 30 lb. skip track had to be replaced with 40 lb. skip track, and the gauge widened from 30 in. to 40 in.

Moving the shaft dividers only required about three months time, then we were able to put in the 40 lb. skip track. The new track was put in on the outside of the old skip track without disturbing it, and the old track was taken out later. By the time the new hoist had been installed this work had been done. Doubling up the footwall sills required about 2½ years time, but most of this work was done after the new hoist and skips had been placed in service. Since we could work in the shaft only on Sundays, complete rehabilitation of the Carlos Francisco shaft required 3 years time.

The new hoist room was cut out directly be hind the old one, and the new cable raise was driven over the old one. The top of the Carlos Francisco shaft lacked 25 ft. of connecting with the new cable raise so we sank from the top of the new cable raise to make the connection. Before making the connection, a heavy bulkhead was placed across the shaft above the old sheave wheels so that no damage would be done the shaft. The new hoist was installed and put into operation with the loss of one hour's time or the time necessary to change over the new skips and to run them up and down in the shaft slowly a few times to see that everything was clear.

The new hoist was placed in service in October 1938. The pump station had already been placed in service. The job has required four years to date. The work left to be finished is to drive the 5400 ft. crosscut on the 3300 level to the Aguas Calientes mine, and to deepen the Aguas Calientes shaft from the 2900 to the 3300 level, which will require two years more time.

GROUTING

The following concrete jobs were grouted: both sides of the two protective bulkheads on the 3300 level, the bottom of the water column around the nipples, and the side of the water column where it passes the 2900 and 3100 levels. The proceedure was to set up a long hole machine and drill a series of 25 ft. holes fan-like around the object to be grouted and then force cement grout into the surrounding rock.

TESTS

Tests were made of all the work after the job had been completed. The water column can be considered watertight since the leakage is less than a gallon per hour. The two protective bulkheads on the 3300 level were tested on numerous occasions by allowing seven to eight millions of gallons of water to accumulate behind them. No leaks of any kind have ever been detected around either of the bulkheads. The pumps have been checked for capacity on many occasions but they have never equalled their rated capacities. Their best performance has been an average of 2200 gallons per minute which is 300 gallons per minute under their rated capacity. However, since the normal flow of mine water never exceeds 10,000 gallons per minute, the pump station has ample capacity.

DETAILED COST OF THE WORK DONE IN

CASAPALCA BETWEEN 1935 AND 1938

Carlos Francisco Shaft 2700 to 3300	$ 70,772.14
Drainage	131,615.06
Ventilation	11,411.53
Installation of Nordberg Double Drum Hoist	52,947.26
Sub-Stations	44,293.71
Total Cost of Installations	$ 311,039.70

CARLOS FRANCISCO SHAFT 2700 TO 3300 LEVELS

SHAFT SINKING

		Feet	Cost per foot
Shaft sinking	$ 29799.82	596.41	$ 49.97
Pumping costs	19080.27	596.41	31.99
Signals, telephones and Lights	1996.24	596.41	3.35
Total	$ 50876.33	596.41	$ 85.30

SHAFT STATIONS

		Cu.Ft.	Cost per Cu.FT.
2900 level station	$ 1596.08	11013.38	$ 0.14
3100 " "	1837.91	17093.09	0.11
3300 " "	1847.56	12571.78	0.15
	$ 5281.55	40678.25	$ 0.13

POCKET

3300 level pocket $ 5680.68

ENGINEERING AND SUPERVISION

Engineering	$ 1119.73
Supervision	7813.85
	$ 8933.58

		Feet	Cost per Ft.
Total shaft costs	$ 70772.14	596.41	$ 120.63

CARLOS FRANCISCO SHAFT 2700 TO 3300 LEVELS

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DETAILS OF SHAFT SINKING COSTS

		Cost per Ft.
2700 Pocket for waste	$ 207.58	$ 0.35
2700 Hoist room	561.44	0.94
Moving and installing hoist	525.77	0.88
New Equipment	510.33	0.86
Preparatory work	484.73	0.81
Shaft sinking	14089.81	23.62
Timbering	6588.83	11.00
Tracks	207.39	0.35
Hoisting	2779.96	4.66
General Expense	3873.98	6.50
	$ 29799.82	$ 49.97

Pumping Costs

		Cost per Ft.
Pumping	$ 12429.60	$ 20.84
Installation pumps 2900 level	552.87	0.93
" " 3100 "	1392.31	2.33
" " 3300 "	86.83	0.15
New Equipment	4296.66	7.20
Installation of industrial hoist for pump	322.00	0.54
	$ 19080.27	$ 31.99

DRAINAGE

3314 PUMP STATION

Pump installation	$	54217.50
Discharge column		17681.56
Top of discharge column and weir		442.87
Total cost of 3314 pump station	$	72341.93
Drainage crosscuts-2700, 2900, 3100 and 3300 levels	$	6397.30
Taking down back and erecting high line 2700 level		583.36

2700 Drainage Ditch

Enlarging ditch	$	8825.64
Concreting ditch		3708.03
Total cost 2700 ditch	$	12533.67
Installation of sump pumps	$	1172.27
Pumping		18271.44
Engineering		1248.53
Bulkheads		19066.56
Total drainage costs	$	131,615.06

DETAILS OF DRAINAGE COSTS

Pump Installation

Cutting 3314 pump station	$ 7911.79
Timbering pump room	4057.60
Making and installing suction for pump	3141.67
Screen chamber	2480.43
Pump foundations	1394.90
Installing pumps	2487.30
Installation on electrical equipment	2736.54
Installation of trash racks	228.70
Flooring pump room	549.98
Painting pump room	360.69
Grouting screen chamber	219.14
Repairs to electrical equipment, 2500 gal. pumps	580.81
Over hauling and repairing Worthington pumps, mechanical	1088.27
Over hauling and repairing Worthington pumps, electrical	365.13
Installation of discharge pipe, 10 in. gate and check valves	1094.50
New equipment	25250.05
Total cost of pump installation	$ 54217.50

Discharge Column

Raises	$ 3429.57
Sand and gravel	844.50
Excavation for hoist and concrete mixer (2700)	415.04
Installation of hoist (2700)	196.74
Installation of bottom of discharge column	414.22
Concreting	7982.64
Stripping and preparing raise for concreting	2177.39
Installation of concrete mixer (2700)	45.24
Excavation of top of discharge column	152.30
Grouting discharge column	1030.31
Installation of underground rock crusher	50.30
Operating of underground rock crusher	943.31
Total cost of Discharge column	$ 17681.56

DRAINAGE CROSSCUTS

Crosscuts to water column 2700-2900-3100-levels	$ 2114.82
Crosscut to bulkhead and screen chamber 3300 level	2319.52
Ditches, tracks and timbering 3300 crosscut to bulkhead and screen chamber	1962.96
Total cost of drainage crosscuts	$ 6397.30

Taking down back and erecting high line 2700 level

Taking down back of crosscut	$ 279.74
Erecting high line	303.62
Total cost taking down back and erecting high line	$ 583.36

Installation of Sump Pumps

Installation of sump pumps	$ 855.08
New equipment	317.13
	$ 1172.27

Details of Bulkheads

2900 Bulkhead with Door

		Cu.Yds.
Excavation	$ 106.72	
Sand and gravel	132.61	
Mechanical work	350.79	
Concreting	681.47	
Total cost of bulkhead	$ 1271.59	46.2

3100 Bulkhead with Door

Excavation	$ 1064.91	
Sand and gravel	616.05	
Mechanical work	625.38	
Concreting	2319.34	
Total cost of Bulkhead	$ 4728.52	146.0

3300 Bulkhead with Door

Excavation	$ 590.35	
Sand and gravel	493.01	
Mechanical work	516.51	
Concreting	1913.04	
Grouting	314.17	
Operating underground crusher	183.23	
New equipment	1698.66	
Total cost of Bulkhead	$ 5708.97	143.5

3300 Bulkhead with Valves

Excavation	$ 780.95	
Sand and gravel	526.05	
Mechanical work	1164.69	
Concreting	2914.96	
Grouting	536.41	
Operation of underground crusher	230.74	
New Equipment	1203.68	
Total cost of bulkhead	$ 7357.48	181.3
Total cost of bulkheads	$ 19066.56	517.0

Ventilation

		Feet	Cost per Ft.
Ventilation crosscut 3300 level	$ 458.81	39.7	$ 11.56
Ventilation crosscut 3100 level	668.86	195.2	3.43
Ventilation crosscut 2900 level	$ 31.08	20.7	1.50
Total cost crosscuts	$ 1158.75	225.6	$ 4.53
Ventilation raise 3300 to 3100	$ 1306.62	166.7	$ 7.84
Ventilation raise 3100 to 2900	1161.57	166.0	7.00
Ventilation raise 2900 to 2700	1097.52	165.4	6.64
Stripping ventilation raises	70.78		
Total ventilation raises	$ 3636.49	498.1	$ 7.30
		Cu.Ft	Cost Cu. Ft.
Ventilation room 2700 level	$ 336.61.	6653.2	$ 0.05
Ventilation room 3300 level	827.24	2803.9	0.30
Total cost ventilation rooms	$ 1163.85	9457.1	$ 0.10
Ventilation equipment and installation	$ 5246.98		
Installation of Ventilation doors and bulkheads	205.46		
	$ 5452.44		
Total cost of ventilation	$ 11411.53		

INSTALLATION OF NORDBERG DOUBLE DRUM HOIST
ON 1700 LEVEL, CARLOS FRANCISCO SHAFT

300 HORSEPOWER-DRUM 7 FEET DIAMETER, 62 In. FACE-1-1/8 In. CABLE

Cutting new hoist room	$ 1442.49
New Hoisting equipment	27793.87
New electrical equipment	5728.49
Raise for cableway	2599.25
Concrete foundation	1914.84
Mechanical installation	1223.31
Electrical installation	1307.11
Guniting hoist room	141.84
Concreting floor in hoist room	287.93
Painting hoist and hoist room	44.14
Total cost of installing hoist	$ 42483.27
Rehabilitation of Carlos Francisco shaft for $3\frac{1}{2}$ ton skips	$ 4527.93
Installation of 40 lb. rails	1999.42
Skips, cables, sheaves, and miscellaneous equipment	3123.82
Installation of tipple and overwind	812.82
Total cost of rehabilitation of Carlos Francisco shaft	$ 10463.99
Total cost of installation	$ 52947.26

BACKUS AND JOHNSTON ADIT

SUB-STATION AND ARMOURED

CABLES

Installation of sub-station	$	21762.14
New Equipment		22531.57
Total cost of sub-station	$	44293.71