CATALOGUE No. 3

... EDITION

Roasting Smelting Refining

Methods Machinery

FRASER & CHALMERS

CHICAGO and LONDON

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CATALOGUE No. 3
4th Edition, June, 1899

Roasting
Smelting
Refining

Fraser + Chalmers.

METHODS
MACHINERY

FRASER & CHALMERS

Manufacturers of

MINING MACHINERY

GENERAL OFFICES

CHICAGO, ILL., U. S. A., 12th St. and Washtenaw Ave.
LONDON, ENG., . . . 43 Threadneedle St.

WORKS

CHICAGO, ILL., U. S. A., 12th St. and Washtenaw Ave.
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Marquette Bldg., Dearborn and Adams Sts.
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NEW YORK
80 Broadway

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INTRODUCTORY

We take pleasure in presenting to our patrons and the mining public this Fourth Edition of our No. 3 Catalogue devoted to illustrated descriptions of the machinery which modern practice has found best suited for the purpose of extracting gold, silver, lead and copper from ores by igneous processes.

Since the earlier days of mining in this country we have been identified with its interests as manufacturers. As pioneers in the industry and during all these years it has ever been our special aim to keep pace with the various improvements that have been made from time to time in mining machinery and to give special attention to the arrangement of our shops and the perfection of our tools and patterns.

Being in constant communication and direct connection with the best and most successful representative men in the various branches of mining and ore treatment generally, throughout this and foreign countries, we are always in a position to learn and take advantage of such suggestions and changes from existing methods as may be found to be of merit and real improvements in the mining and treatment of ores.

Our large shops were overcrowded from the tremendously increased business which we had done in recent years, and we have built new shops in Chicago that have over three times the capacity of our former shops. We have also built new shops with large capacity at Erith, Kent, England.

We now have the largest shops in the world devoted exclusively to the manufacture of mining machinery. These shops are equipped with the best and most improved tools and a very large and varied assortment of patterns and plans. We are in a position to produce first-class work to the advantage of our trade, and do it more promptly than ever before.

Our facilities for the manufacture of Sectional Machinery adapted for transportation on pack animals in mountain districts are unexceled. We have made this a special feature, and have not only had a great deal of experience in the manufacture of such machinery, but have also a very full and complete line of improved patterns.

Our patrons may rest assured that we will not allow the reputation we have acquired as manufacturers of mining machinery to slip from us by failure to do good work or to keep up with this age of progress. They may rely upon us in obtaining the most practical outfits, and not mere experimental machinery when desiring to purchase standard and successful mining and ore reducing appliances.

Mining plants, reduction and smelting works, etc., for which we have furnished all the machinery, can be seen in operation in every state and territory in this country where mining is followed. Besides this we have many plants in operation in Alaska, Canada, Mexico, Central and South America, China, Japan, Australia, Norway, Hungary, Spain, Portugal, Russia, South Africa, India, Italy and the Philippine Islands.

Attention is called to the list of our other publications on the inside back cover of this catalogue.

These catalogues are sent post free to parties having a practical interest in the reduction and treatment of ores.

We make all machinery required for the mining and metallurgical treatment of gold, silver, lead and copper ores, and parties contemplating the purchase of such machinery will find it to their advantage to write to us for estimates and specifications.

FRASER & CHALMERS.

CHICAGO, ILL., June, 1899.

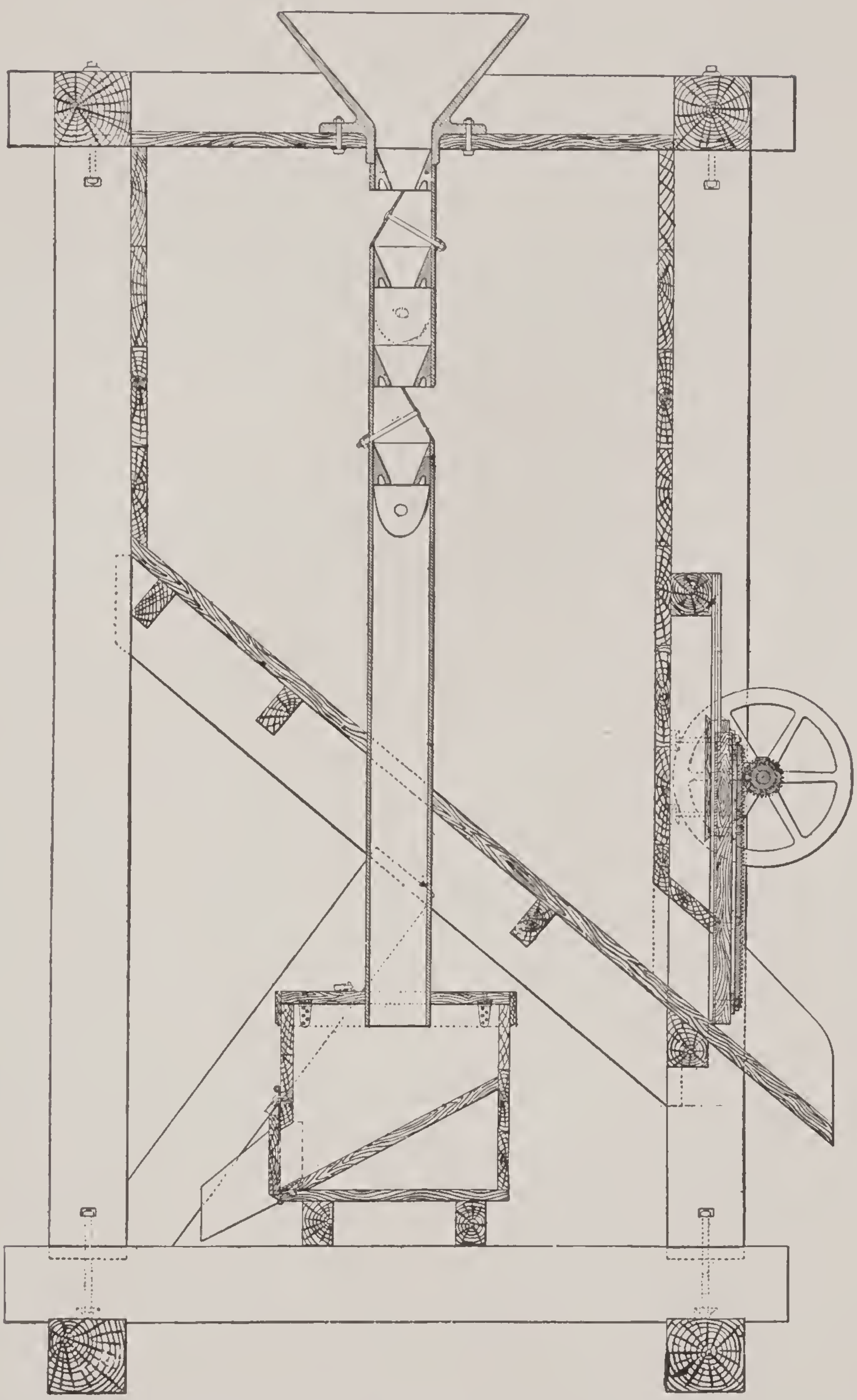
SAMPLING

The value of a mine is determined from the analyses and assays of average samples of the ore. Ores are bought and sold from samples. Ores are combined with fluxes and smelted, the analyses of samples furnishing the metallurgist with data from which to calculate proper blast furnace charges. Ores can be sampled by hand or by machines, the former being the old-fashioned and expensive method, the latter, the modern method employed in sampling works.

Every smelting plant should be equipped with machinery for sampling.

We give descriptions, with illustrations, of some of the best machines used for automatic sampling.

Plate 502.



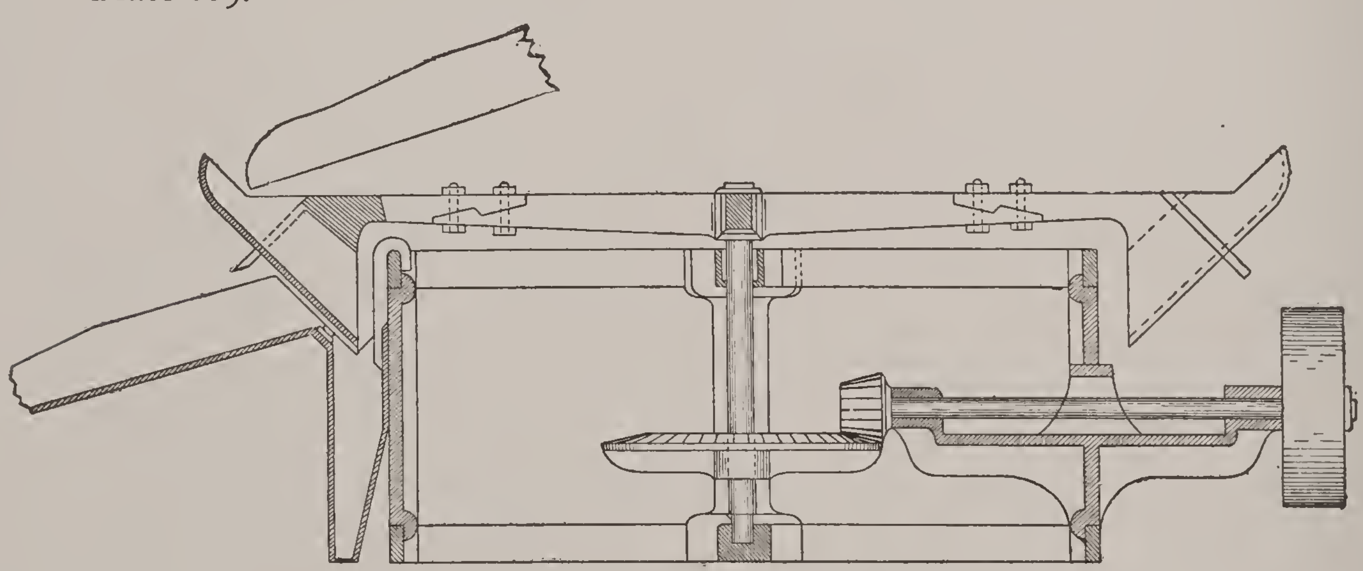
THE PIPE ORE SAMPLER

This apparatus consists of a vertical pipe some 8 in. in diameter, provided with diaphragms near the top and surmounted by a funnel-shaped hopper; the sampler is usually placed in a bin. Plate 502 represents such a sampler.

The finely crushed ore is fed into the hopper and passes over a dividing diaphragm which cuts it into two equal parts, one half being discharged into the ore bin, while the balance descends in the pipe and is thoroughly mixed by passing into a funnel, below which, it encounters a second diaphragm, which cuts it into equal parts, one half being discharged into the bin while the other half is mixed by passing through a funnel, cut into halves, etc. The plate shows how the ore and sample are collected and removed.

This apparatus, while lacking the fine accuracy and great capacity of the Bridgman machines, will be found to serve a useful purpose where a less expensive plant is required and where power is not convenient.

Plate 869.

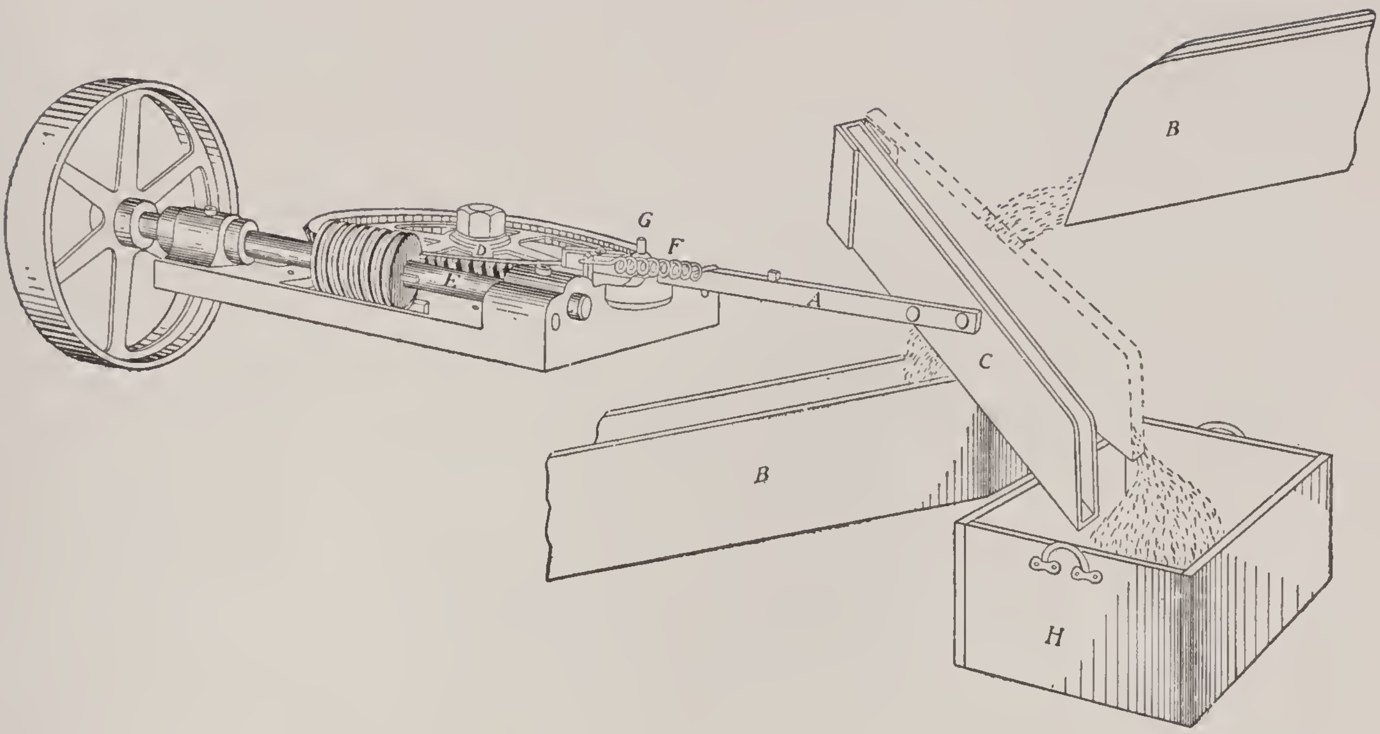


COLLOM'S SAMPLING MACHINE

This machine (Plate 869) is used for taking, automatically, an average sample of ore below crusher or rolls as a check on the work of a mill.

The arm with inclined channel revolves slowly, cutting an equal sample at regular intervals from the stream of ore falling from the rollers, all the samples being mixed and quartered down at the end of the day or run.

Plate 503.



McDERMOTT'S AUTOMATIC SAMPLER

Plate 503 shows the McDermott Automatic Sampler, the construction and operation of which will be clearly understood from the following description :

The worm wheel *D* revolves constantly, and pin *G* coming in contact with lever *A*, moves spout *C* into the stream of ore or pulp, causing a small portion of the current to be directed for an instant into the sample box *H;* the pin *G*, having then passed the lever, it returns to original position by spring *F*.

1. This arrangement of long-armed lever *A* with spring return enables the use of a slow revolving wheel, *D*, so as not to take samples too frequently, nor too large; so that the machine can run all day and not take too bulky a sample for convenient handling. The dividing launder splits up the stream of pulp in a large mill for the same purpose, viz., to keep sample small by passing sample spout *C* through only a part of the stream.

2. The machine can be adapted to existing mills where "fall" is limited, either by making a few inches drop at some point in the main launder carrying pulp or tailings, or,

if this is not practicable, by using a long dividing launder, *BB*, which, being narrow and of metal, will clear itself with less fall than the main wooden launder.

3. The frequency of the samples can be indefinitely increased by adding pins to the gear wheel *D*, or increasing speed of worm shaft *E*.

4. The size of each sample taken can be varied by the widths of dividing launders and of sampling spout *C;* these being of thin sheet iron, can be bent by hand to desired width.

5. Machines can be driven by 1-inch rubber belt from any convenient line of shafting without any pulley on latter, simply letting shaft itself act as pulley and so giving slow motion to worm shaft.

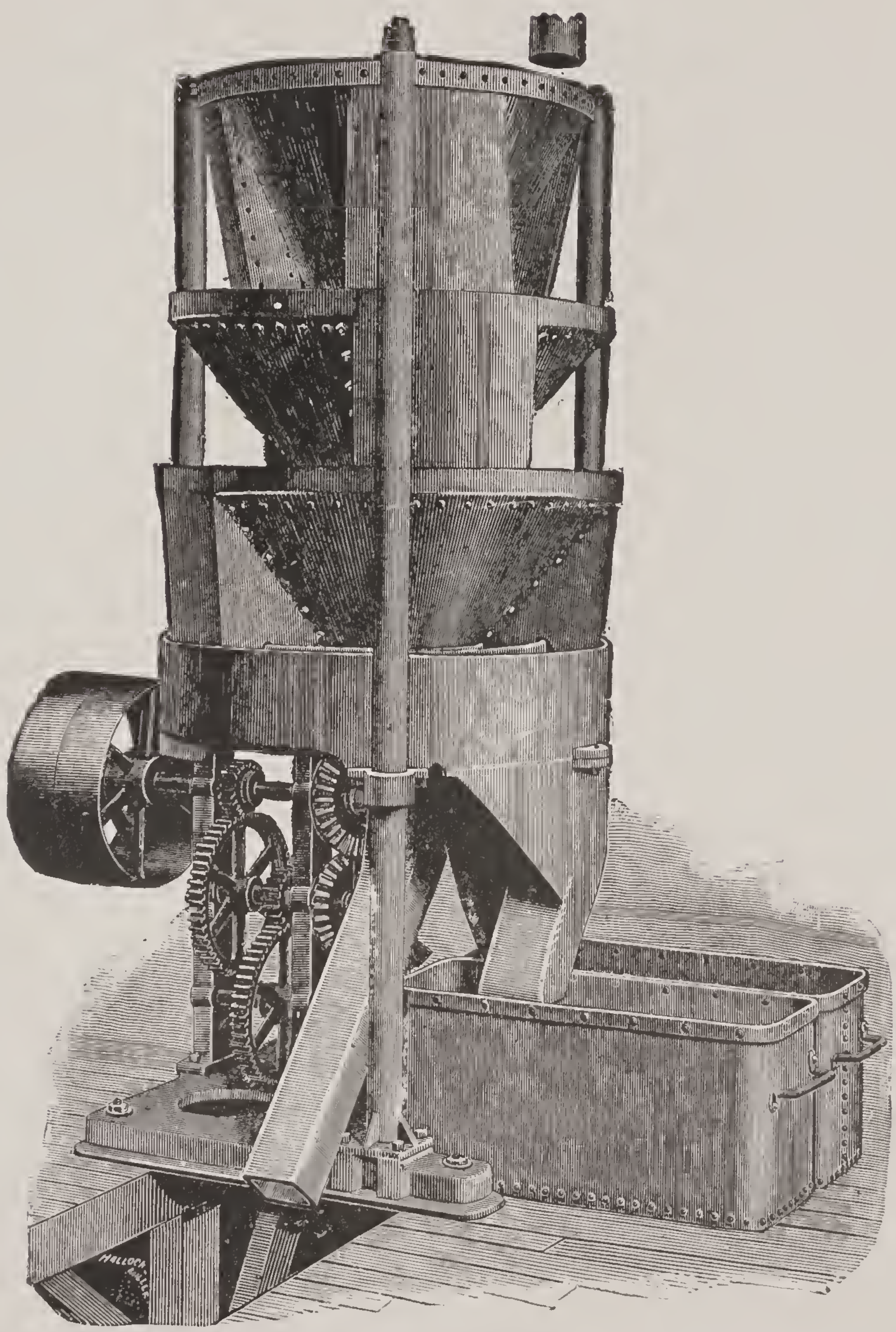
6. The dividing launder is not necessary where very small streams of pulp have to be sampled.

7. The machine does more regular and more accurate work than the usual plan of sampling by hand. It has been tested for over a year in New York on all kinds of gold and silver ores—sampling pulp of a stamp battery, tailings of a concentrator, and discharge of a settler after pan amalgamation. This last is the most severe test a sampler can be put to, because settler discharge is extremely irregular. Its accurate work on the settler discharge has been proved in a great number of tests by check assays made on pan sample taken before discharge into settler.

8. Every mill should have one to sample the pulp and one to sample the tailings. Great losses may be saved by systematic and accurate sampling in a mill. Millmen can not be trusted to take regular samples, and in some mills such great variations in daily assays occur that any estimate of actual work being done is little more than a guess.

9. Machine being light and self contained can be bolted to the side of any main launder, or bolted on to any piece of timber supporting the launder.

Plate 234.



THE BRIDGMAN ORE SAMPLING MACHINE

Sampling, to be of value, must be accurate and independent of personal influence. By using an automatic sampling machine not only are the inaccuracies of hand labor avoided, but the cost of the operation is greatly reduced.

Mr. H. L. Bridgman, M. E., has given to the mining world a most valuable machine which accomplishes all to be desired in an ideal automatic sampler. This statement is substantiated by abundant evidence from our patrons. The machine is constructed on the best scientific principles. It is the result of years of practical experience.

Plate 234 shows the general appearance of the machine.

It affords a method of sampling far in advance of any other, either by hand or by machine. Following are the principal advantages:

1. It gives entirely independent double (duplicate) samples on every lot of material, affording the best possible control of results, and rendering "salting" impossible.

2. It gives three or more cuts (quarterings) on each sample during a single passage of the material, thus yielding practically finished samples in one operation.

3. It is the only machine that does these things, and both points are broadly covered by United States and foreign patents.

4. It samples according to the only correct principle of taking the entire stream of material for certain predetermined periods of time, and does not attempt to take a portion of the stream for the whole time.

5. It is entirely self contained and very compact.

6. It takes its feed directly from the crusher, and gives good results, equal to the best hand sampling, under any ordinary working conditions.

7. It requires not more than the power of one man to run it.

8. It requires no lubrication, except at long intervals.

9. It requires a minimum of repairs.

10. It will sample any material that can be crushed, even up to 10 per cent. or more of moisture.

11. It can be thoroughly cleaned by one man in fifteen minutes.

12. It may be fully inspected during operation without the necessity for the near approach of any person. This will avoid suspicion of unfairness by enabling those who desire to watch the work.

13. It requires not over one-tenth the space that hand sampling does.

14. It reduces the cost of sampling to one-tenth that of hand-work, and does not, like present methods, require the use of the best judgment and the greatest vigilance, but rather a mere faithful performance of routine.

15. It is free from all personal influence and entirely impartial, thus avoiding disputes.

16. It gives final samples so quickly that all lots may be sampled and disposed of as soon as received. This quickness, furthermore, makes it possible to use the machine samples for moisture determinations as well as for the metals, thus saving work and getting fairer assays.

17. It is adjustable and gives larger or smaller final samples, as may be required by the different grades and kinds of material.

The following sizes of machines and apparatus have been designated to meet the various requirements :

Machine "A"

Gives double samples and three cuts (quarterings) on each sample. It is intended for original samples of any size, and gives final samples of about 1 or 2 per cent. of the original weights. It requires a floor space 3 by 4 ft., and has a height over all of 7 ft. 6 in. Its average capacity is about 20 tons an hour.

Machine "B"

Gives a single sample and three cuts. It is intended for smaller original samples than the "A" machine, and for work requiring only a single sample, as, for instance, iron ores, the various furnace supplies and products, etc. It is especially designed for the cutting down of the crushed final samples from the "A" machine. It occupies a floor space about 18 in. square, and is about 36 in. high. Its average capacity is 2 to 4 tons an hour.

Machine "D"

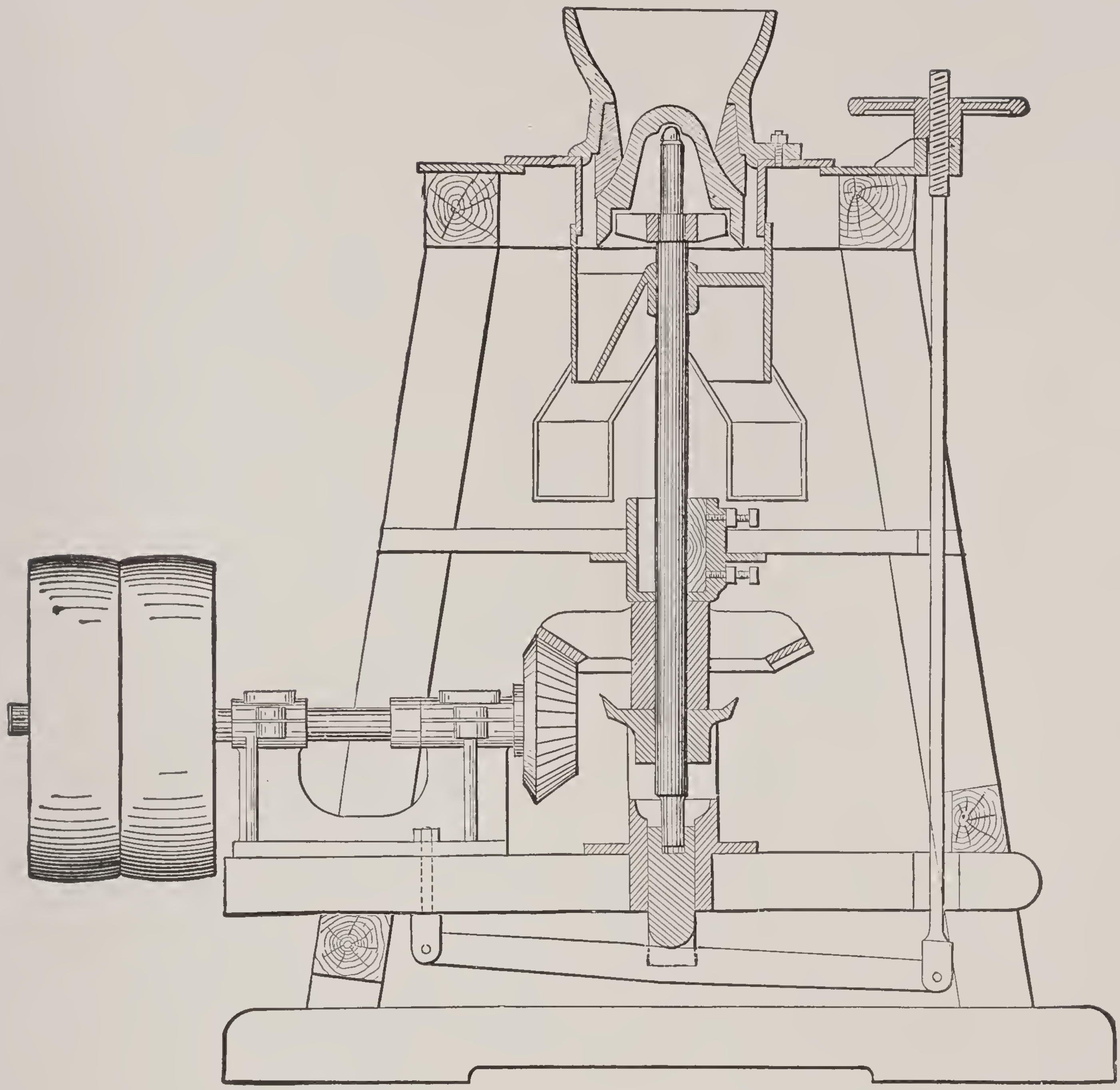
Laboratory sampler for small work.

Mixer and Divider

For the final preparation and distribution of the assay samples.

A full description of the Bridgman Ore Sampling Machines, illustrated with cuts, as well as valuable information relating to sampling, is contained in our Pamphlet No. 32A, copies of which will be sent on application.

Plate 56.

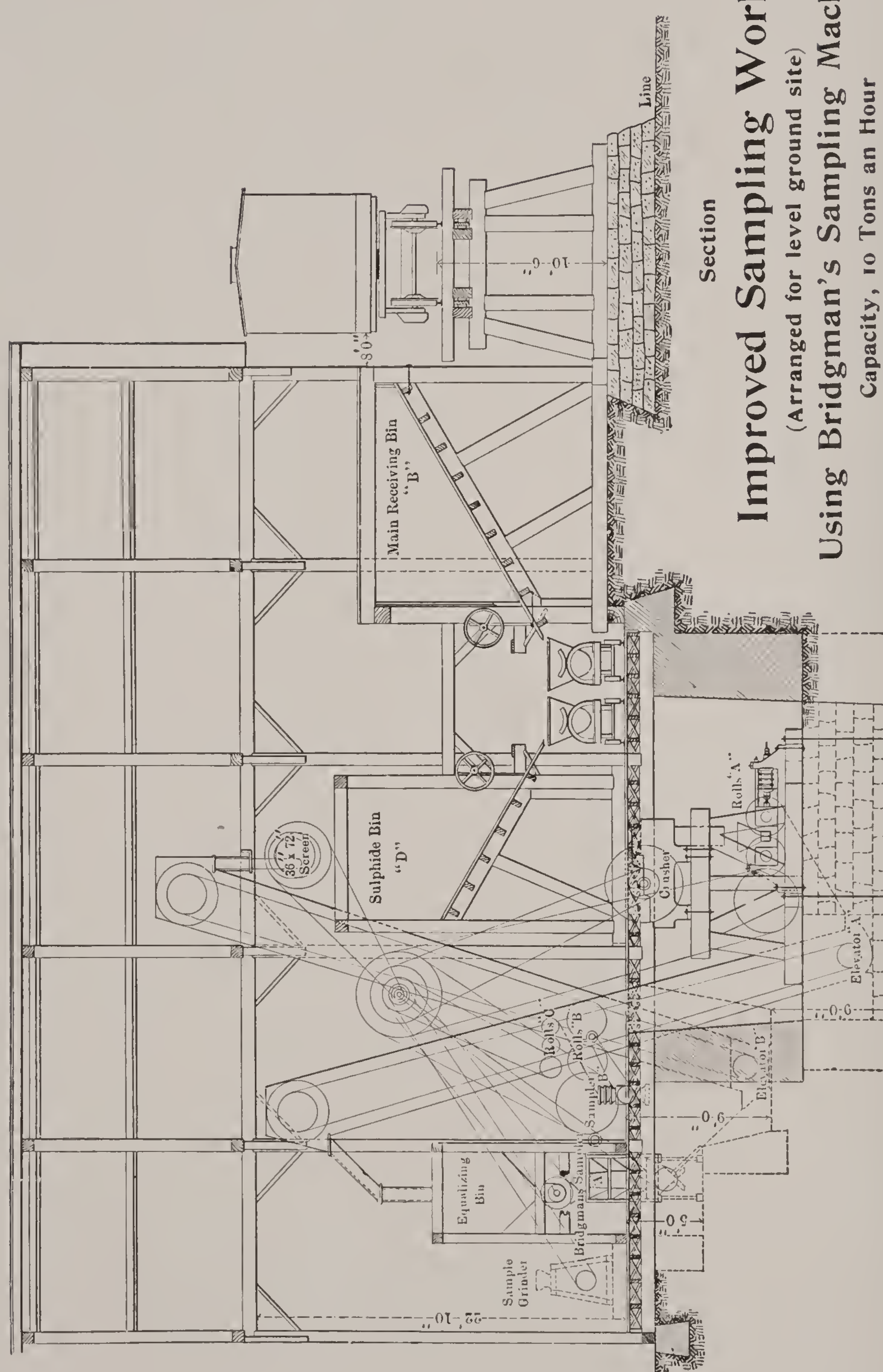


SAMPLE GRINDER

Plate 56 illustrates our Sample Grinder. This is a very useful machine in any works, and is especially necessary in a custom mill. The coarsely crushed sample for assay is rapidly ground to fine powder, and is caught below in pans from two spouts; the distributing case and spouts are dust-housed; cleanliness is thereby assured and the escape of dust prevented. The degree of fineness can be regulated by the hand-wheel shown in the cut.

The Sample Grinder is sold complete and ready for belt.

Speed.	Diameter of Pulleys, Tight and Loose.	Face of Pulleys.	Weight, Not Boxed.	Weight, Boxed.	Horse Power.
150	16 in.	4½ in.	775 lbs.	900 lbs.	3



Section

Improved Sampling Works

(Arranged for level ground site)

Using Bridgman's Sampling Machines

Capacity, 10 Tons an Hour

Plate 245

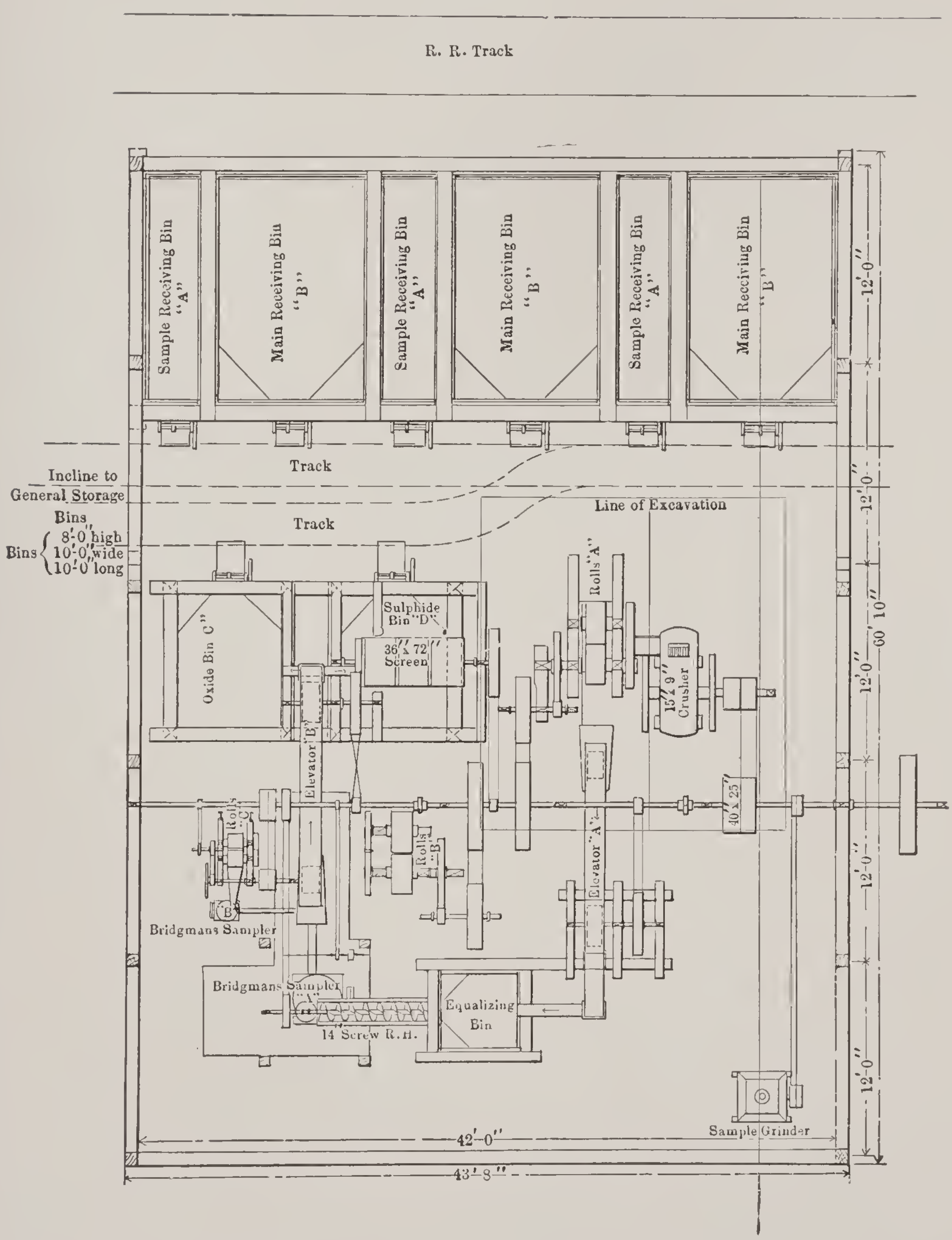


Plate 246

Ground Plan

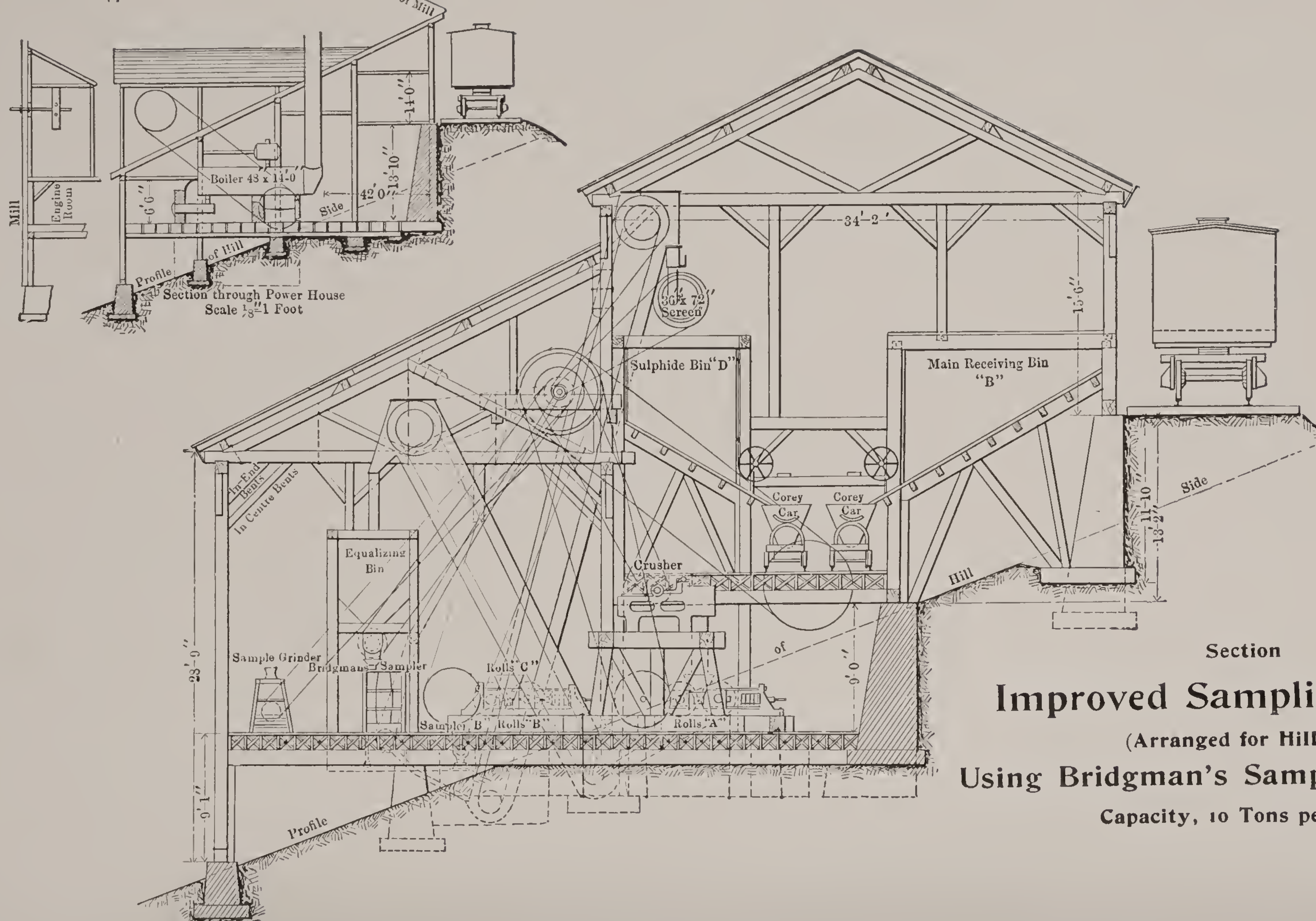
Improved Sampling Works

(Arranged for level ground site)

Using Bridgman's Sampling Machines

Capacity, 10 Tons an Hour

Plate 247



Section

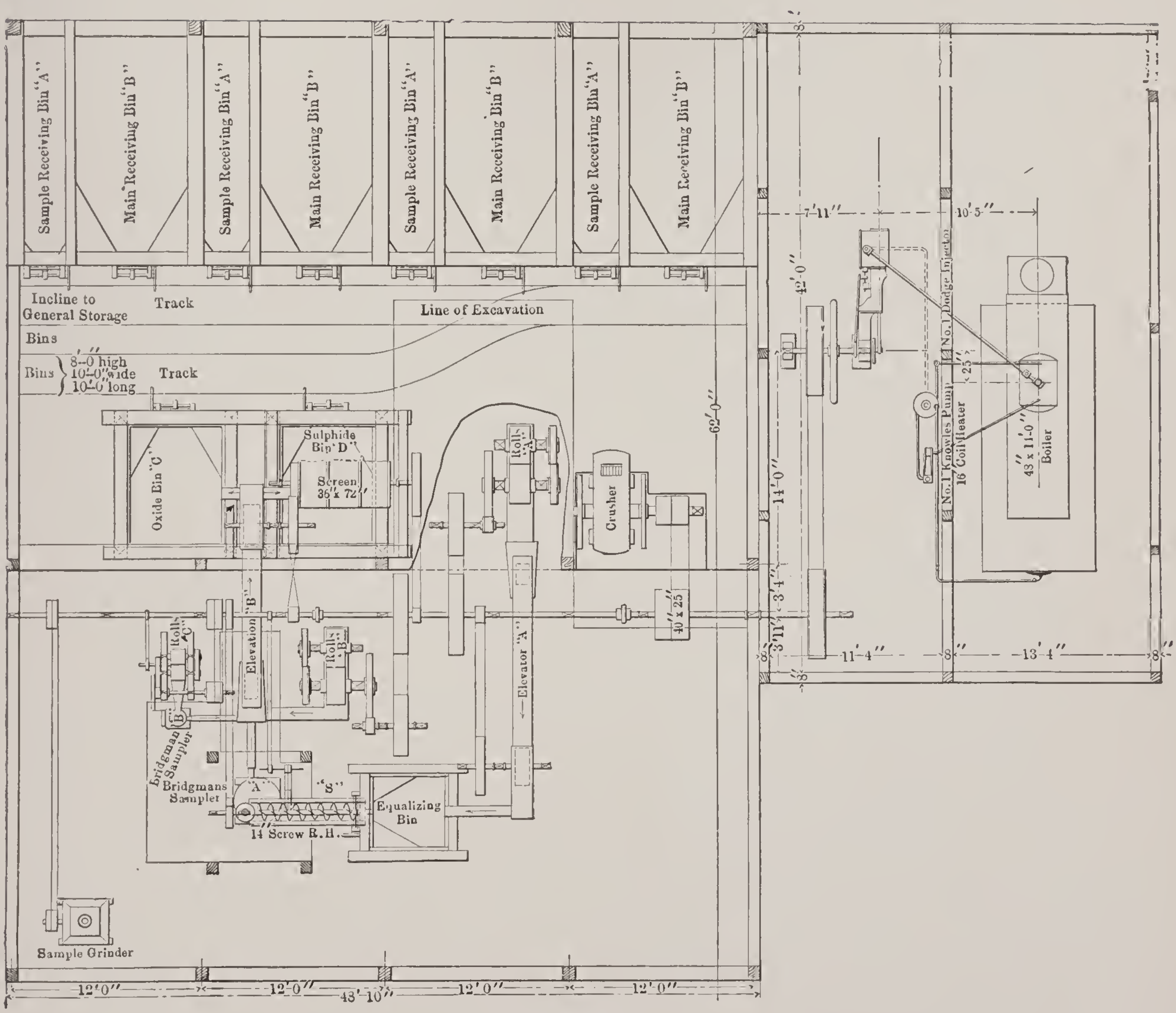
Improved Sampling Works

(Arranged for Hillside)

Using Bridgman's Sampling Machines

Capacity, 10 Tons per Hour

Plate 248



Ground Plan

Improved Sampling Works

(Arranged for Hillside)

Using Bridgman's Sampling Machines

Capacity, 10 Tons per Hour

SAMPLING WORKS

USING BRIDGMAN'S SAMPLING MACHINES

Capacity, 10 Tons an Hour

The following explanation applies to the plans both for LEVEL GROUND (Plates 245 and 246) and for HILLSIDE (Plates 247 and 248), the general arrangement being the same for both:

These Sampling Works are designed to handle both oxide and sulphide ores at a rate of about 10 tons per hour, of material actually sampled, provided the ores be not excessively hard to crush. For sulphides it is generally desirable to sample the entire lot, and this course is also strongly advised for oxides of high value and of which it is desired to obtain very accurate samples. This is rendered unobjectionable because of the fact that the arrangement followed herein permits of the sampling of an entire lot in less time and at less cost than would be required for the sampling of one-fifth of the lot by hand, with the further advantage of greatly increased accuracy in the finished samples. In case, however, it is desired to preserve the oxides in a coarse lump form rather than to obtain greater accuracy of sample, the main bulk of the lot is thrown into bin "B", while such fractional part of said lot as may have been predetermined is thrown into bin "A", as the "first rough sample", which then is passed to the sampling, the main bulk going by cars to the general storage bins or to whatever point desired. It is advisable to limit maximum size of ore passing to Automatic Sampler to not more than two inches, ring gauge. Whichever course be adopted, either the main bulk or the "first rough sample" would be subjected to the following treatment which is that for Oxide Ores: The ore is taken from bin by dump car to crusher, into which it is fed by hand as regularly as possible, avoiding rolls "A" (supposing crusher to be set for two inches or less), and passing to elevator "A". Thence it rises to equalizing bin (by means of which conveyor trough "T" is always to be kept full), and is fed regularly by screw "S" to Bridgman's Automatic Sampler "A" which cuts out duplicate "first finished samples" of proper and variable size and discards the bulk which passes to elevator "B". This "discard" then rises and is deflected to bin "C" and goes thence by dump car to general storage bins. The duplicate "first finished samples" are then hoisted from below and treated separately, each being crushed very finely by small rolls "C" and then cut into "second finished sample" and "discard" by Bridgman's Automatic Sampler "B", the former going to the F. & C. Sample Grinder and thence to the Assay Office, and the latter being delivered to bin "C" by means of elevator "B" as in the case of the main bulk.

Sulphide Ores: These as a rule and for obvious reasons, require to be crushed very finely both for sampling and for subsequent treatment, although it is permissible to crush somewhat coarser for the former than for the latter. In order to avoid all segregation by sizing until after the sampling has been finished the following order is to be observed: The entire lot of ore is taken from bin "B" by car to crusher, from which it passes to rolls "A" (set for ½ or ¾ inch), thence to elevator "A", equalizing bin, and Automatic Sampler which cuts out duplicate "first finished samples", the "discard" going by means of elevator "B" to revolving screen (¼ mesh) over bin "D" into which the undersize falls and is taken by cars to general storage bins. The oversize falls to rolls "B" (set fine), and thence to elevator "B", by which it is again raised to screen for sizing. The "first finished samples" follow the same course as that taken by those from the oxides. For public sampling, the rolls "B", bin "D", screens, etc., may be dispensed with, since the second fine crushing is not demanded. As it stands, the plant is arranged for smelting works.

Roasting

Methods
Roasting Furnaces

Reverberatories
The Brown Furnaces
Brückner Roasters
White-Howell Roasters
Stetefeldt Roasters
Muffle Furnaces

ROASTING

Roasting is oxidation under the influence of heat in the presence of air, its object being to effect such chemical changes as will render the material suitable for smelting, amalgamation or lixiviation. By this operation sulphur and arsenic are more or less eliminated, as well as some antimony and zinc.

Ores in the lump form which contain sufficient sulphur may be roasted in heaps, stalls, or kilns, or, if crushed, in roasting furnaces. Lump ore containing as little as 15 per cent. of sulphur can be roasted in heaps without the admixture of considerable fuel through the rock.

Roasting operations may be classed under one of three heads: OXIDIZING, CHLORIDIZING and SULPHATE ROASTING.

OXIDIZING ROASTING

Sulphide ores and mattes can be subjected to the operation of oxidizing roasting in either a lump or a pulverized condition. Those intended to be smelted are often roasted in the lump form in either heaps, stalls, or kilns. Roasting in this manner is not as perfect as when the ore is pulverized; but the lump form is preserved and the disadvantage of smelting fine material in the blast furnace avoided.

To avoid the objection to charging fine roasted ore into the blast furnace, sulphides are often first roasted and then slagged, both operations being performed in the same reverberatory furnace; in this case, the ore must be of such composition that it will slag under a higher heat than is required for roasting, or other ores must be mixed with it to produce a slagging mixture.

Again, to avoid charging fine roasted ore into the blast furnace, certain ores, such as galena, are raised to a high heat at the last stage of the roasting whereby they become sticky and agglutinate, and when cold the mass can be broken up into lumps.

In smelting plants, flue-dust is a difficult and expensive by-product to handle, and is often charged into the slagging pit of a roasting fusion reverberatory furnace and incorporated with the slagged ore, which avoids the necessity of bricking it.

Oxidizing roasting prepares ores and mattes for many subsequent metallurgical operations, some of the principal ones being the following:

For Chlorination

Gold often occurs so associated with other substances (usually sulphur, arsenic, antimony, etc.) that, to extract it, the ore must first be roasted.

The roasting of auriferous iron sulphurets is a simple operation. The material may be either ore (in which case it must be previously crushed) or sulphurets obtained by concentrating the pulp from stamp mills. Upon the thoroughness of the roasting, or, in other words, upon the perfectness with which the sulphur is eliminated, depends more or less the complete extraction of the gold by chlorine.

For roasting sulphurets for chlorination, reverberatory furnaces, either stirred by hand or mechanically (the Brown roaster), are almost exclusively used.

For Cyanide Process

Some ores which in their raw state do not yield a high percentage of extraction when leached with cyanide solution, do so after having been roasted.

For Smelting

By roasting ores previous to smelting, much sulphur and arsenic will be driven off, which will reduce the amount of iron otherwise necessary to be added in the blast furnace to decompose the sulphides and arsenides, and with it the amount of matte and speise, thus increasing the capacity of the furnace.

As a rule, ores containing as much as 15 per cent. of sulphur should be roasted previous to smelting; the richness of the ore in silver may, however, modify this rule on account of the loss of silver in roasting.

Silver ores containing as much as 100 ounces of silver per ton are seldom roasted.

When there is much blende in the ore it should be roasted, as in the form of oxide it more readily passes into the slag.

Copper sulphide ores produce a higher grade matte if roasted previous to smelting them. Copper mattes are often roasted and then smelted with silicious ores in order to slag off the oxide of iron; this concentrates the matte and brings it up to a percentage of copper which permits of it being either shipped or bessemerized.

CHLORIDIZING ROASTING

Chloridizing roasting consists in roasting the material, (whether it be an ore or a matte) with common salt, the metal which it is desired to extract being obtained in the roasted product in the form of chloride; in the case of silver, the silver chloride can then be extracted by amalgamation or by lixiviation with sodium hyposulphite.

Chloridization in the roasting furnace is effected by the action of the sulphuric acid of the sulphates formed by the oxidization of the sulphides on the salt which liberates chlorine, from which it will be seen that for successful chloridizing roasting there must be a certain percentage of sulphurets present in the raw ore.

Chloridizing roasting is confined principally to silver ores, and for this operation the ores must necessarily be pulverized.

SULPHATE ROASTING

Ores and mattes are sometimes roasted without salt, the silver contents being converted into silver sulphate and then leached with water (Zievogel process). There are also processes for extracting copper in a similar manner.

Plate 818

The Guyer Desulphurizing Kiln

THE GUYER DESULPHURIZING KILN

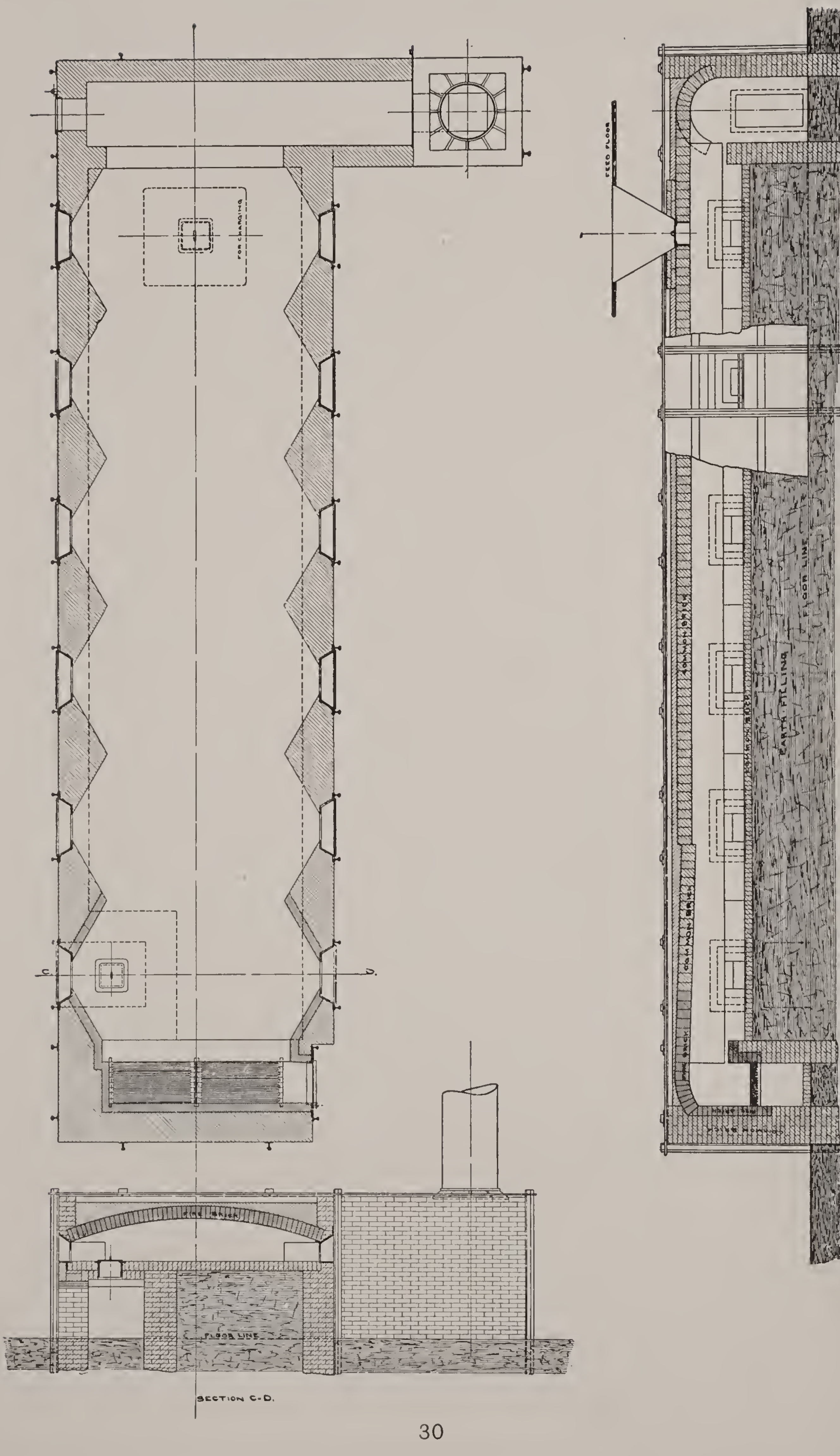
In small plants where development of the property does not warrant expensive crushing and roasting machinery, and where the ores are suitable for heap or stall roasting, "The Guyer Desulphurizing Kiln" (Plate 818) can be used to advantage for the purpose of partial desulphurization.

Capt. Henry Guyer, of Casapalca, Peru, has had several of these kilns in operation for some time with excellent results. In a letter under date of November 15, 1898, he writes us that he ran one of these kilns at the rate of seven tons per day at a cost of 34 soles (33 cents silver) per ton, and that in one week in October of the same year he ran at the rate of thirteen tons per day at a cost of 18 soles (18 cents silver) per ton. The original ore contained 27 per cent. of sulphur, and was reduced by roasting to 8.8 per cent.

Ores to be roasted in this furnace must be coarse, from the size of corn to about the size of an egg, and should not contain less than 20 per cent. sulphur. The only fuel used is a few shovels daily of charcoal dust, shavings, or any rubbish that will burn.

We make these kilns of as small a capacity as two tons per day.

The furnace is very simple, consisting of a four-sided grizzley, constructed principally of grate bars fastened to a rectangle made of rails, which is supported on pipe columns; this is surmounted by a sheet-iron hood having a hole in the top for charging and one on the side for connection with a flue.



Reverberatory Roasting Furnace

Plate 776

ROASTING FURNACES

Roasting furnaces may be classified under one of the following types: the hand-stirred reverberatory; the reverberatory with continuous discharge (Brown); the revolving cylinder with intermittent discharge (Brückner); the revolving cylinder having continuous discharge (White-Howell); shaft furnaces (Stetefeldt); muffle furnaces (Brown).

With the above mentioned furnaces, wood, coal, gas, or oil can be used as a fuel, and all are intended for roasting crushed ore.

THE REVERBERATORY FURNACE

The ordinary reverberatory roasting furnace consists of a continuous hearth covered over with a low arch and having a fire-box at one end and a flue at the other.

The furnace can often be economically built of stone up to the hearth level, the rest of the structure being constructed of brick and the entire mass bound together with "T" rails and wrought iron tie rods.

The hearth should be of sufficient area to suit the character of the ore and the tonnage required. We make them all the way from 7 x 10 ft. to 17 x 72 ft.

Plate 776 shows the general construction of a reverberatory roasting furnace in plan and elevation.

Ore is charged into the furnace through a hopper and gradually advanced from the cool end to the hot end by means of iron paddles and rabbles, and when roasted it is raked out into a car or wheelbarrow, or into a pit.

Reverberatory furnaces are sometimes built with the hearth in steps, that is, beginning with the fire-box end, every 10 or 15 feet lengthwise of the hearth being raised a few inches higher than the preceding section. This construction permits of keeping the charges in the furnace entirely separate from each other; it is also claimed that, by dropping the ore through the air from one hearth to the next, roasting is facilitated.

Reverberatory furnaces are sometimes built with half the length of the hearth placed over the other half, thus forming a two-tier furnace; they have also been built in three tiers. Some mechanically stirred reverberatories, especially those used for roasting zinc where the fumes are recovered and converted into suphuric acid, are made even six tiers high.

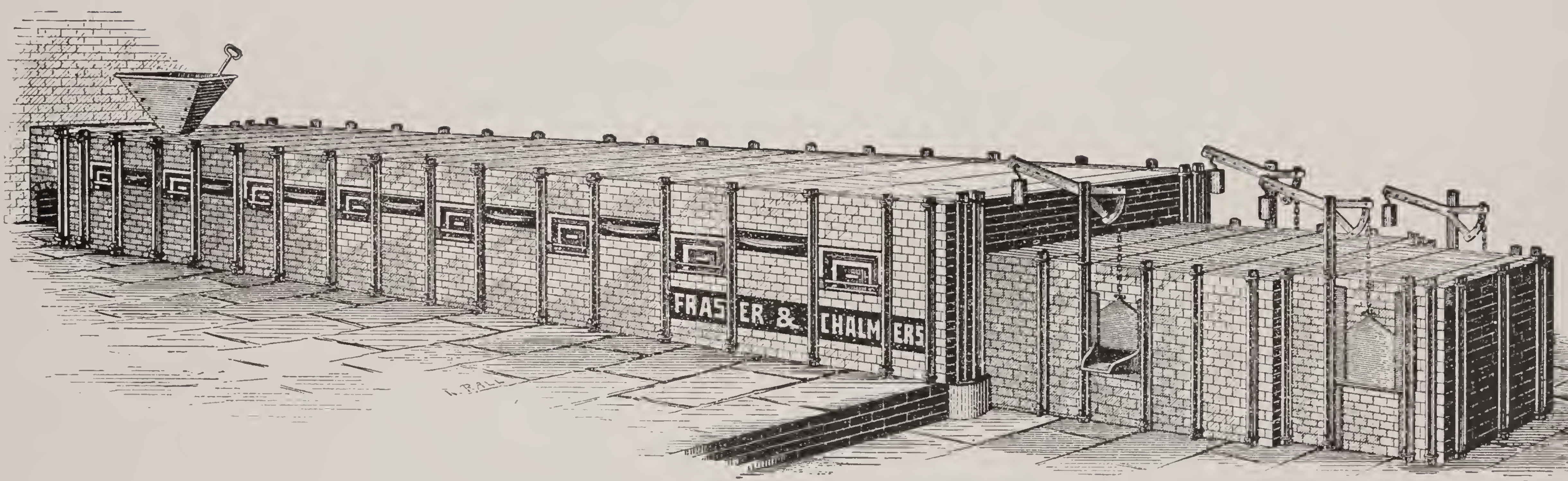
Again, two reverberatories may be placed side by side, the central wall being common to both furnaces; in this case the furnaces can be worked from one side only.

The advantage of the hand-stirred reverberatory is that its first cost is small; the disadvantages are, that roasting is expensive and the results obtained are irregular.

THE SLAGGING-REVERBERATORY

The slagging-reverberatory, or roasting-fusion furnace, Plate 57, is largely used by smelting companies. It consists of a long, brick hearth, sometimes built in "steps" covered over with a low arch, and terminating next to the fire-box in a fusion-box, or slagging pit. As a high heat is carried in the slagging pit, the fire-bridge is usually provided with a water-jacket or coil of water pipes. Ore is charged into the upper end through a hopper and gradually worked forward, being roasted during its passage, as in the ordinary reverberatory roaster, until it reaches the fusion-box, where, being subjected to a high heat, it is fused or slagged down; from the fusion-box it is drawn out at intervals into slag pots, cooled, broken up, and charged into a blast furnace.

Plate 57



The Slagging-Reverberatory Furnace

Plate 57 illustrates a furnace of this type which has given great satisfaction at the works of the Omaha & Grant Smelting and Refining Co., the Hanauer Smelting Co.'s works, and elsewhere.

These furnaces are built in various sizes; the one we have represented is 72 ft. long by 17 feet wide.

The capacity of a reverberatory roasting furnace depends chiefly upon the percentage of sulphur the ore contains and the delicacy of the roasting required. Heavy galena ores and pyrites roasted for smelting require from 85 to 92 sq. ft. of hearth area per ton of ore roasted per 24 hours; fine pyritic concentrates roasted for chlorination require about 169 sq. ft.; in the former case the roasting is imperfect, there being left in the roasted ore from 3 to 5 per cent. of sulphur, while in the latter less than one-half of 1 per cent. is permitted to remain.

Roasting by hand is hard work and requires conscientious labor, results are often very irregular and unsatisfactory, and the cost of roasting is much more than in mechanical roasters.

Experience having proved that the reverberatory is the best type of roaster for nearly all classes of ore, many have studied to invent mechanical means to take the place of hand labor. Of the many inventions in this direction, "The Brown Roaster" is by far the best, its uniform results, arrangements for admission of air in the proper places, proper distribution of heat, etc., permitting of a large reduction in hearth area over that of the common reverberatory, which means that, for a certain duty, a smaller furnace, less ground room and building, and less labor will be required.

Plate 781

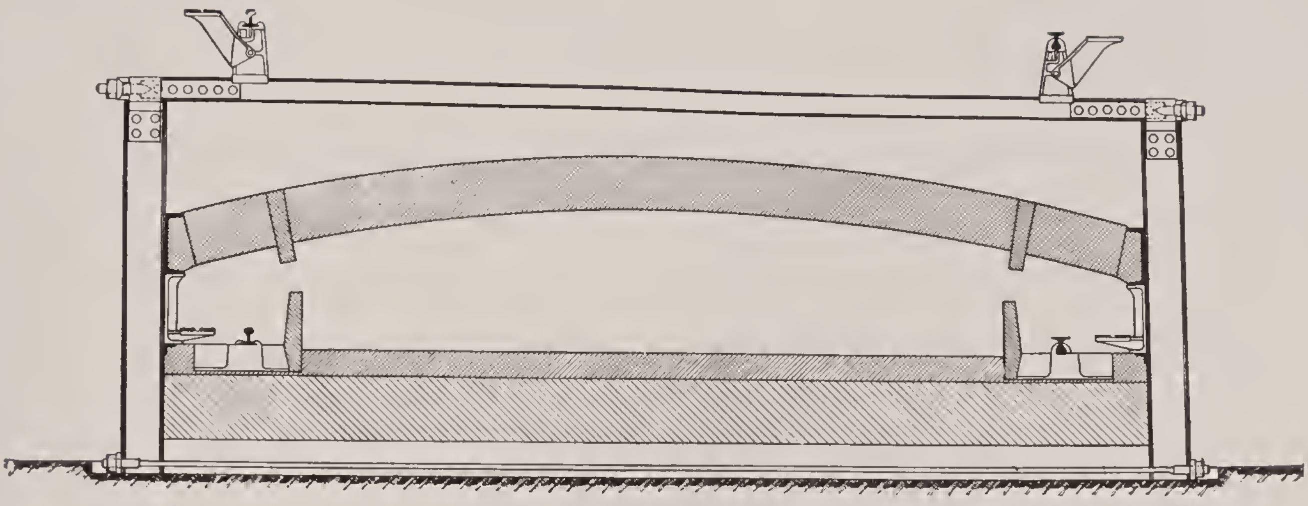


Fig. 1.

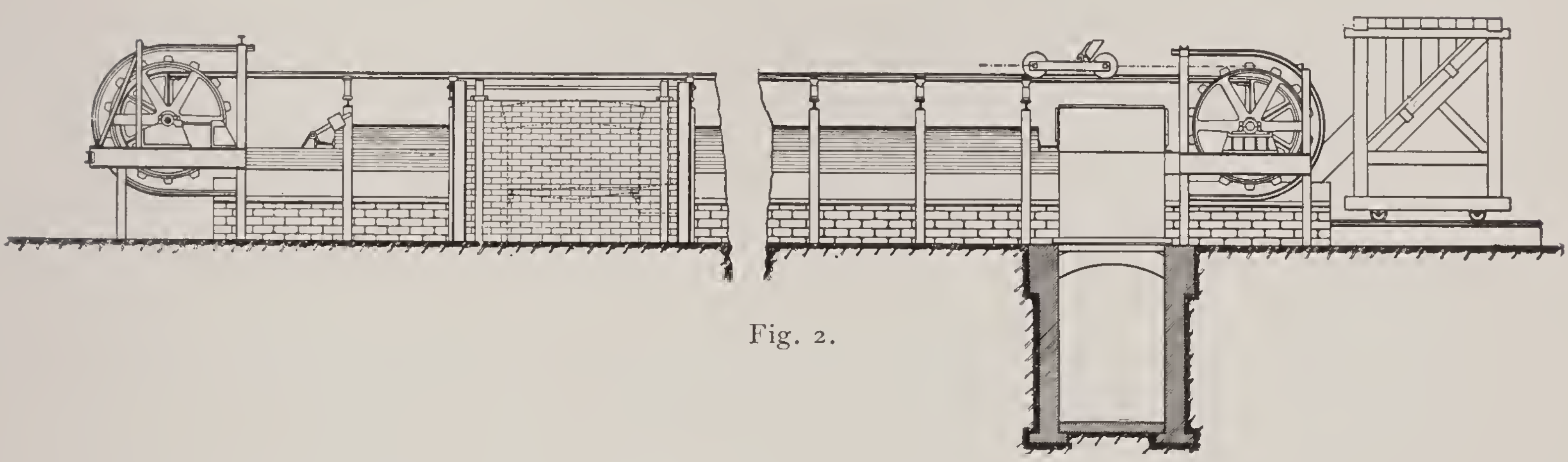


Fig. 2.

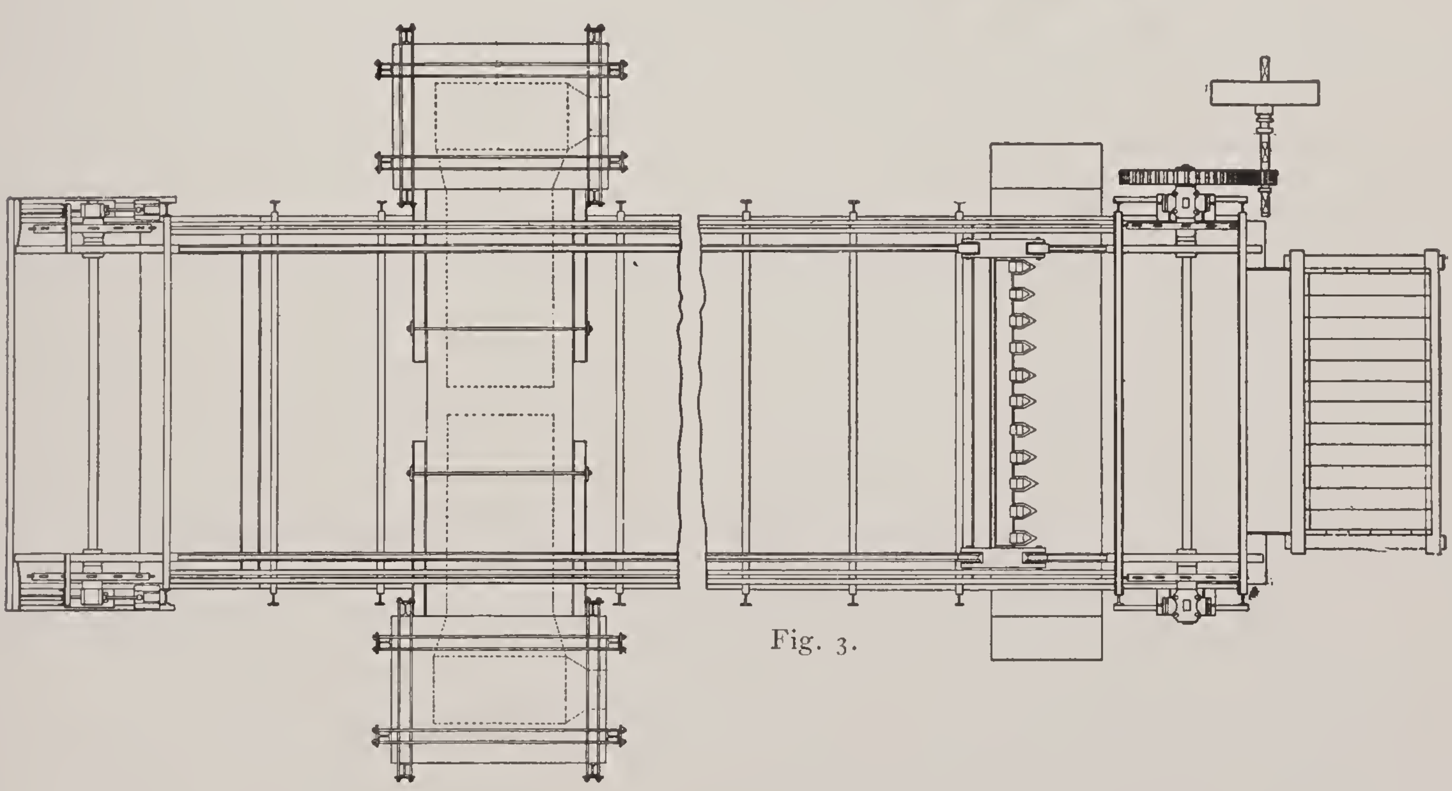


Fig. 3.

The Brown Straight Roasting Furnace

THE BROWN ROASTING FURNACE

In its most improved form the Brown Roasting Furnace is a single hearth reverberatory with an interior slotted wall on each side of the hearth, covered with a low arch (see Plate 781, Fig. 1).

In the conduits formed by the slotted walls and the exterior walls of the furnace, are placed rails upon which run trucks supporting a stirrer arm, projecting through the slots. Fastened to that portion of the arm which extends over the hearth are stirrer shoes, resembling miniature plow-shares, which dip down into the ore, lying in a thin layer on the hearth.

The stirrer carriages (there are never less than two) are moved through the hearth in the direction of the fire-box by two endless steel link chains which pass over sprocket wheels located at both ends of the furnace outside of the roasting hearth (see Fig. 2). After passing through the hearth each carriage returns over the top of the arch in the direction of the flue on tracks similar to those placed in the conduits (see Fig. 1), and having reached the end of the arch it passes downwards into the hearth again. There are sheet iron flap doors, hinged at the top, placed at both ends of the roasting hearth to keep out the cold air; these remain closed except when lifted by a stirrer carriage passing in and out.

By this construction the operating mechanism is protected from the furnace heat and fumes, and the carriages, by passing over the top of the furnace into the open air, have time to cool off. With this provision for cooling, the stirrers do not become over-heated.

The slotted walls are formed by fire-clay tiling which project upwards from the hearth and by firebrick which project downwards from the arch.

The skew-backs of the arch are steel channels supported on short columns, the spaces between the columns being 3 ft. 6 in. long by 12 in. high, these openings extending the entire length of the hearth, forming a continuous slot on both sides; they are closed by sheet-iron doors lined with asbestos. This construction permits of ready access to the hearth at any point for repairs, etc., without having to tear down the brick construction to get to the interior of the furnace.

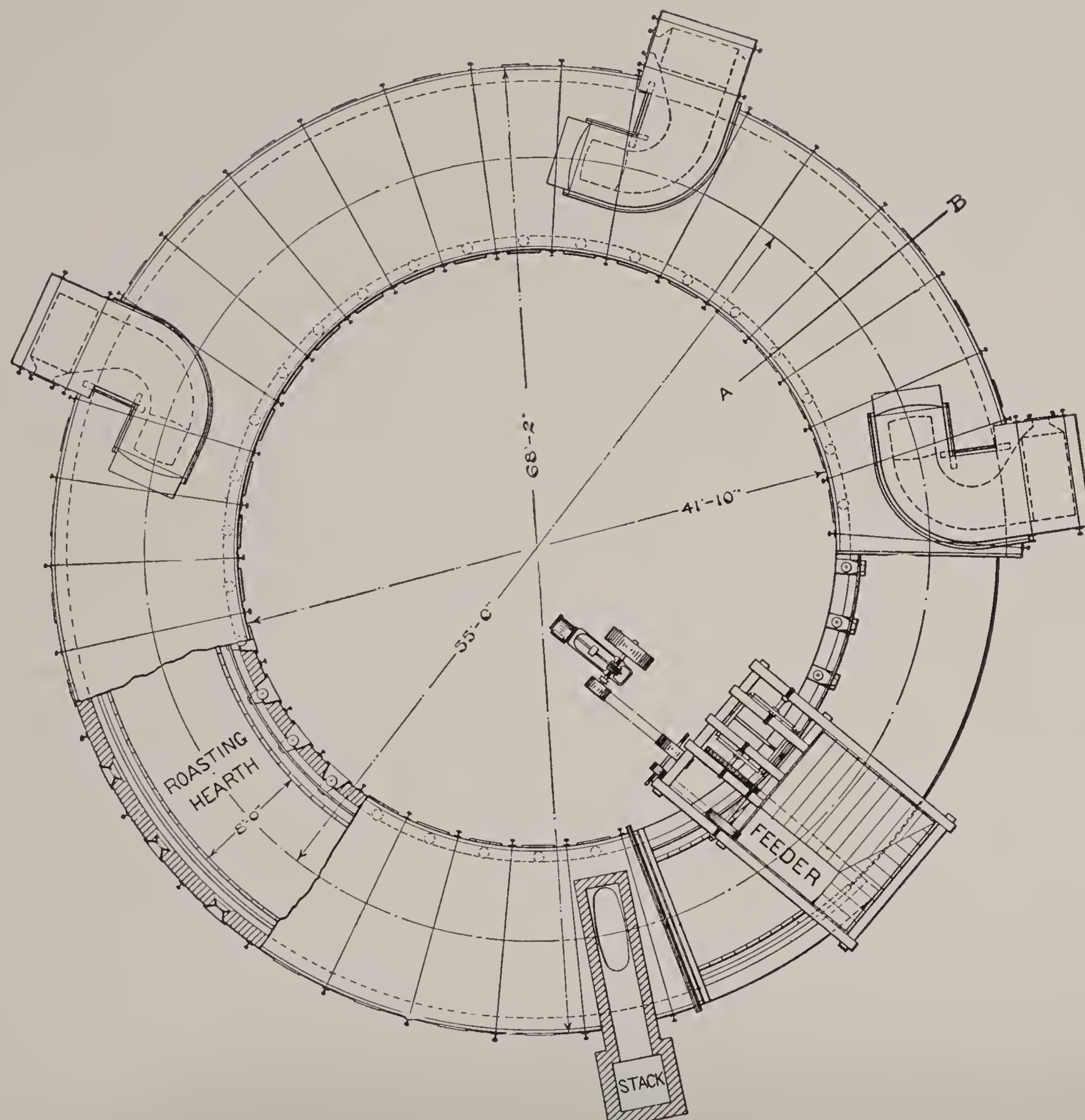
From the ground to the hearth the furnace may be conveniently built of uncut stone, and the rest of the furnace constructed of brick, the structure being bound together by steel I beams.

By the stirrers passing over the top of the furnace instead of underneath, as is the case with several other mechanical furnaces, the furnace can be built lower and therefore more convenient, and the absence of air space beneath the hearth means reduced loss of heat by radiation and hence economy in fuel ; less iron work, consequently cheaper construction.

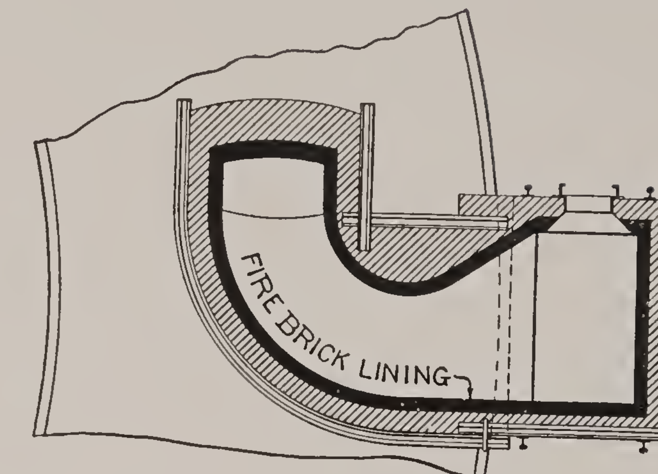
Fire-boxes, in number and position to suit the length of the furnace and the character of the ore, are provided; they are arranged in pairs opposite each other in the usual construction (see Fig. 3).

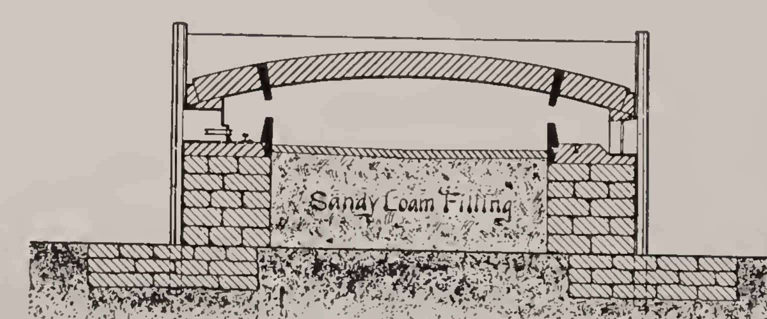
When subsequent operations, such as chlorination, leaching, etc., render it necessary to cool the roasted ore rapidly, the top of the furnace is converted into a cooling floor by covering it with thin steel plates having upturned edges, the construction being that of a shallow tray the length of the arch and the width of the roasting hearth; special double arm stirrers are provided with which to raise the ore from the roasting hearth to the cooling pan along which it is

Plate 563



SECTIONAL PLAN OF FIREBOX AND FLUE INLET.





SECTION A-B.

The Brown "Horseshoe" Roasting Furnace

gradually advanced, in the same manner as in the hearth, to the cool end of the furnace, where it may be carried away by a conveyor or other device. The ore, red hot when leaving the roasting hearth, is in this manner rapidly cooled and can be directly charged into barrels, tanks, etc.

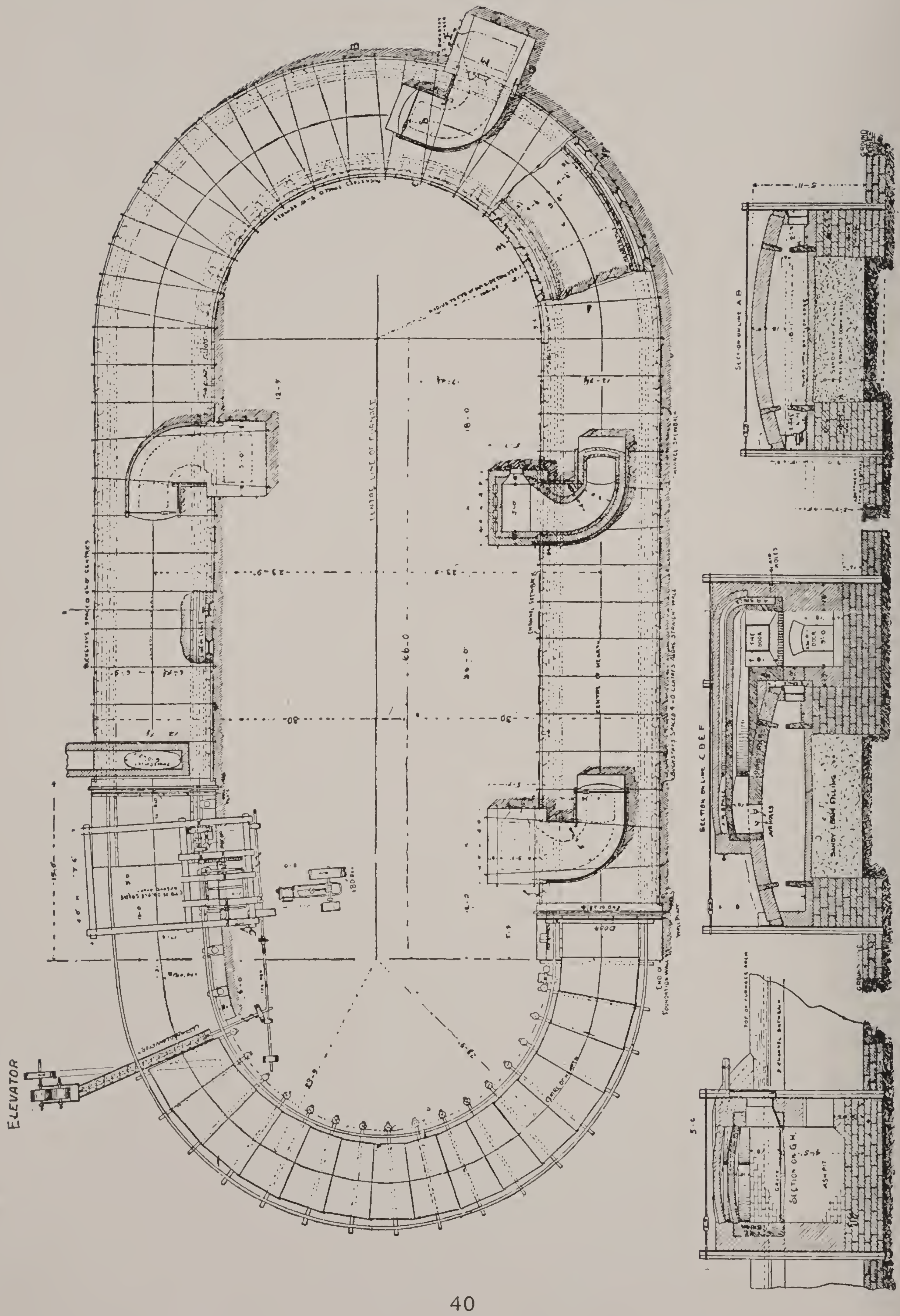
With this furnace we provide an automatic ore-feeder and all driving mechanism complete, also a small slide-valve engine, enabling the furnace to be run independently of the other mill machinery.

The Brown Roaster is also made round in shape, as shown in Plate 563, oval as in Plate 564, and in fact of any desired shape to suit local conditions.

When made other than straight, the stirrer carriages are drawn by an endless steel wire rope which runs in the inner conduit and is supported on small horizontal grooved wheels placed sufficiently near each other to cause the rope to conform to the curve of the furnace; the rope is driven and kept taut by passing it around a system of wheels driven by a small slide-valve engine provided for that purpose.

The rope is connected with the carriages by means of a small grip similar to that used on cable cars and is made to open and shut automatically, the construction being such that as soon as a carriage emerges from the hearth into the open air it is unclutched and remains there cooling off until the carriage behind it emerges and strikes it, pushing it forward a short distance to a point where it becomes again clutched to the rope and travels forward while the second carriage becomes unclutched and remains stationary. These operations are performed automatically.

As can be readily seen, in these designs of the furnace, the carriages travel constantly on the same horizontal plane. Should it be desired to have a cooling-hearth, then enough of the hearth must be left uncovered to serve this purpose.



The Brown "Oval" Roasting Furnace with Cooling Hearth

Plate 564

SIZES OF BROWN ROASTERS

We have found from experience that in the straight furnace the best width for the actual roasting hearth is 10 ft., and for the furnaces which have a curved hearth, 8 ft. The straight furnace may vary from 60 ft. to 180 ft. in length, and the diameter of the round ones may be from 50 ft. upwards. In localities where economy in floor space need not be considered, the round or the oval type may be used, being simpler in construction and costing less per square foot of hearth area than the straight furnace.

Where space is limited the straight furnace should be used.

We recently sold two Brown Roasters of the round or "horseshoe" type, each 119 ft. in diameter, and each having 2,422 sq. ft. of effective roasting hearth. Plate 830 is a photographic reproduction showing these furnaces in process of construction.

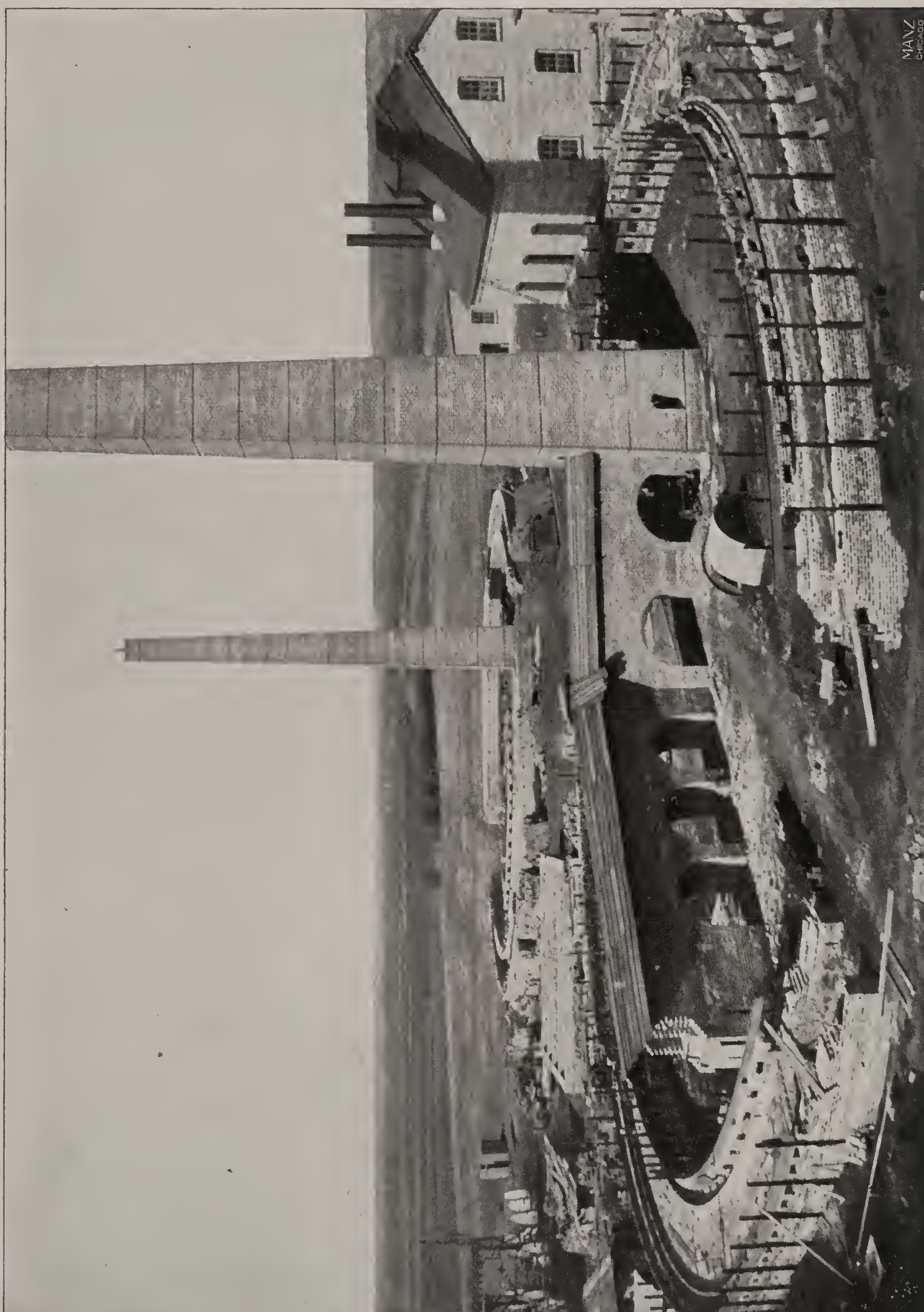
No regular building will be necessary; over the arch will be a roof (preferably of corrugated iron), the central space being left open.

CAPACITY OF BROWN ROASTERS

Silicious ores containing from ½ to 3½ per cent. of sulphur will require from 13 to 15 sq. ft. of hearth per ton; mattes which usually contain from 18 to 20 per cent. sulphur, when it is required to bring the sulphur down to about 4 per cent., need about 45 sq. ft.; sulphide ores roasted for smelting purposes require from 33 to 35 sq. ft. For roasting iron sulphide concentrates which carry from 35 to 45 per cent. down to $\frac{5}{10}$ per cent. sulphur, from 55 to 60 sq. ft. will be required.

From these data it will be easy to select a Brown Roaster of the proper size for any required duty.

Plate 830



The Brown "Horseshoe" Roasting Furnaces

Built for the Edgar Zinc Co. Photograph taken during erection. Each furnace is 119 ft. diameter and has 2,422 sq. ft. effective roasting hearth.

FUEL REQUIRED FOR BROWN ROASTERS

From 100 to 135 lbs. of coal are required per ton of silicious ore and about half that amount for concentrates roasted down to about 4 per cent. of sulphur.

When it is necessary to roast sulphide ores and mattes to below 1 per cent. of sulphur a higher heat and more fuel will be required, the fuel expense increasing in proportion to the perfectness of the roasting.

ADAPTABILITY OF THE BROWN ROASTER

All ores and mattes in a pulverized condition which have to be roasted for subsequent metallurgical operations can be satisfactorily roasted in the Brown Roaster.

POINTS OF SUPERIORITY OF THE BROWN ROASTER

Simplicity of construction, large capacity, uniformity of results, economy in fuel and labor, cheapness of first cost (efficiency considered), small flue-dust loss, durability, readiness and cheapness with which repairs can be made, and portability, a most desirable feature when transportation is necessary to a distant locality difficult of access.

THE BRÜCKNER ROASTER

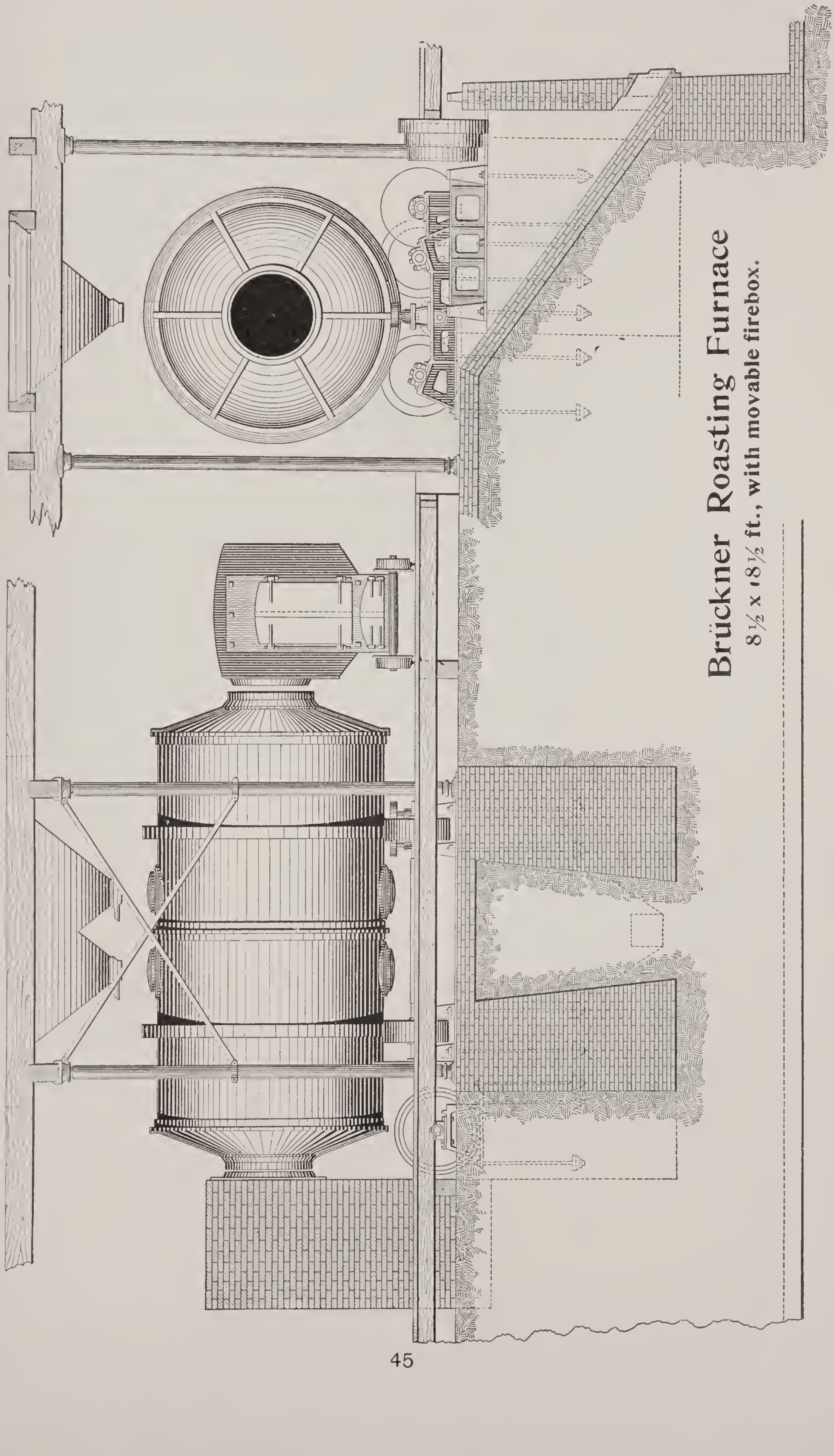
This well and favorably known type of roaster consists of a horizontal cylinder of boiler iron, lined preferably with fire-brick, the cylinder resting on friction rollers and revolving between a fire-box and a flue. The flame from the fire-box passes directly through the cylinder, and thence, mixed with the gases from the ore, into a dust chamber. The cylinder is provided with manholes for receiving and discharging ore.

Plates 194 and 188 show the construction of the Brückner Roaster.

The cylinders are made to revolve slowly, the smaller ones by applying power to a shaft carrying the friction rollers, the large ones by a pinion which engages a spur-gear surrounding the cylinder. The fire-box is made either movable or stationary. In the former case it is constructed in the form of a car running on a track, usually (but not invariably) placed at right angles to the axis of the cylinder, and having a short flue on one side that comes exactly opposite the throat of the furnace. In this way the fire-box can be run in front of a cylinder containing a fresh charge and fired until the sulphur is thoroughly ignited, and then run opposite another cylinder, leaving the first to complete the combustion of the sulphur with free access of air undisturbed by reducing gases which would necessarily pass through the fire-box. After the combustion of the sulphur, for its perfect elimination extraneous heat will be required, and the fire-box can again be placed in front of the throat of the cylinder (see Plate 194).

For ores low in sulphur, requiring the application of extraneous heat during the entire operation, a fixed fire-box may be used (see Plate 188).

Plate 194



Brückner Roasting Furnace

8½ x 18½ ft., with movable firebox.

Brückner Roasting Furnace

7 x 18 ft.

With Stationary Fire-box

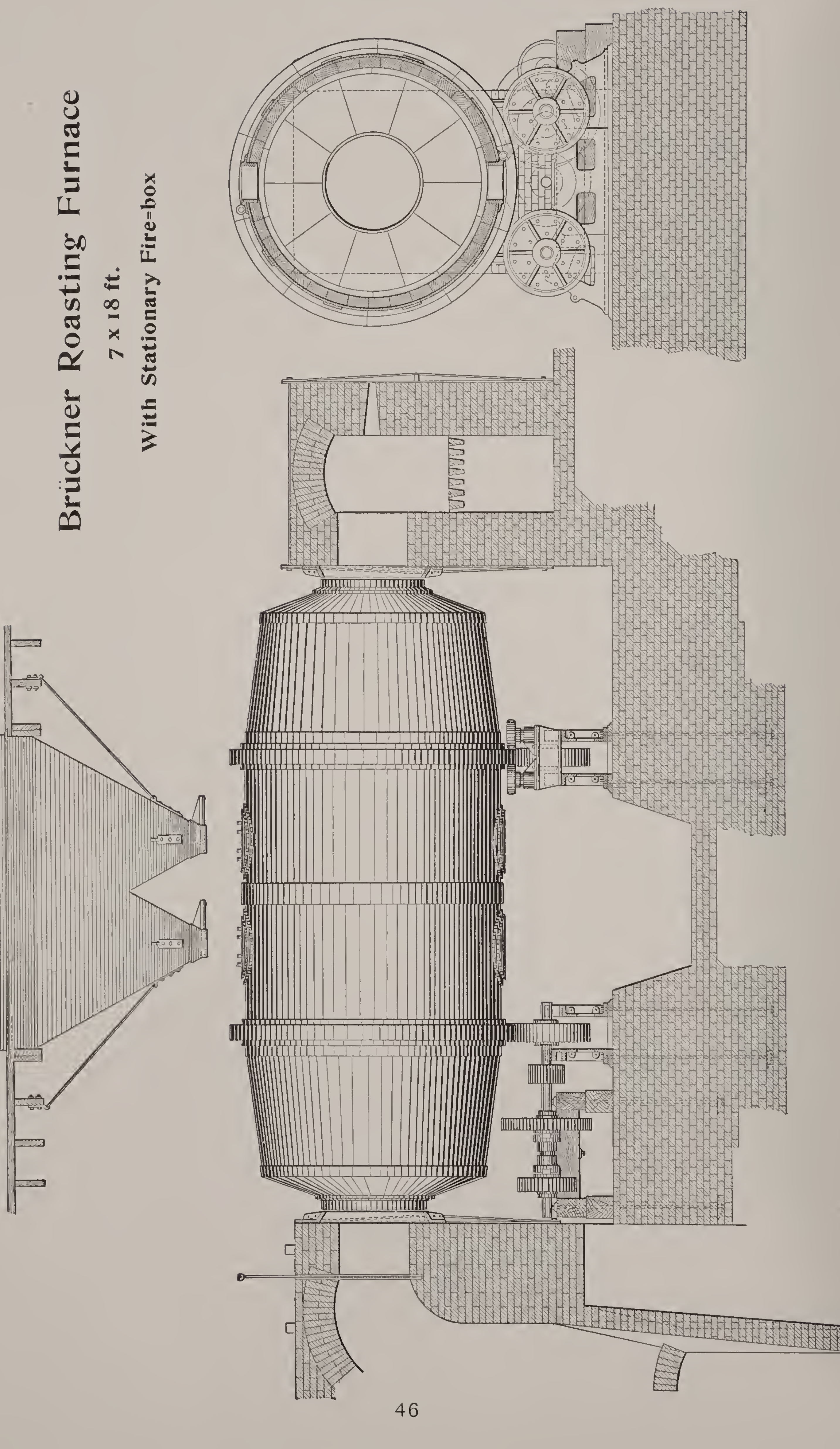


Plate 188

Ore is roasted in this furnace in charges of several tons, and the charge be retained in the cylinder as long as required, the time depending upon the character of the ore, thoroughness of the roasting required, etc., varying from four to twenty-four hours.

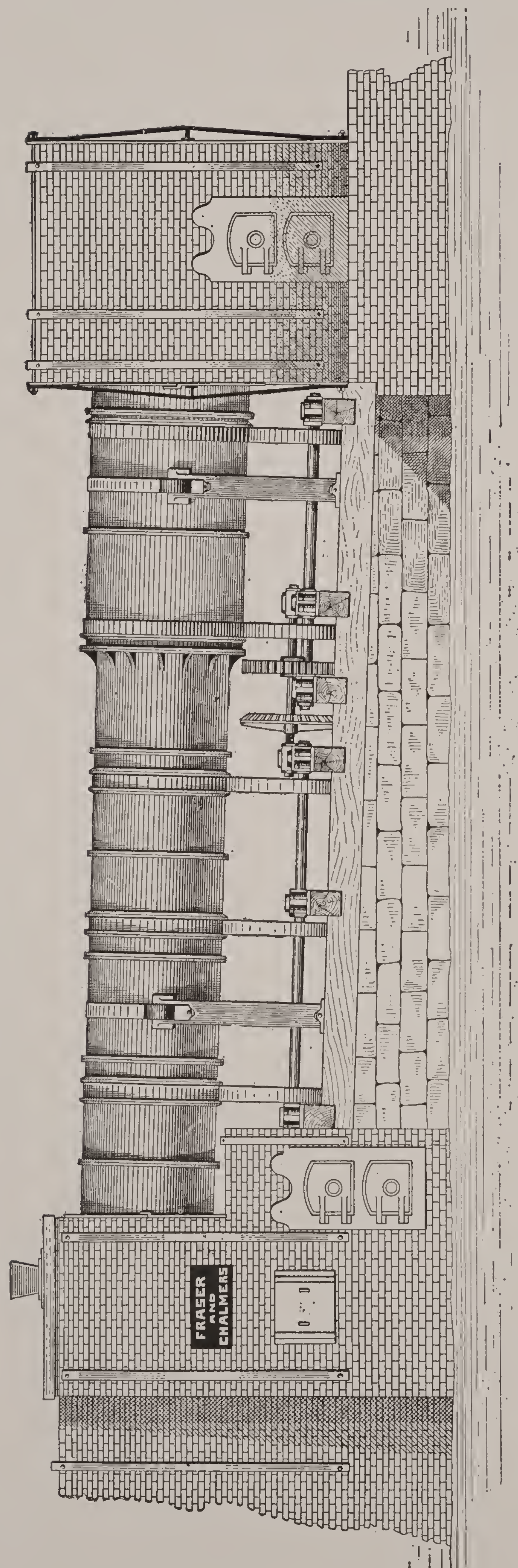
Brückner Roasters have been in use many years and are very popular with smelting companies; to the Anaconda Copper Mining Co. alone, we have sold 252 Brückners, 8½ ft. by 18½ ft.

The principal advantages of this type of roaster are that the charge can be held in the furnace as long as may be required, the heat can be nicely adjusted, and roasting can be economically performed.

We make this roaster in several sizes, from 32 in. diam. by 60 in. long, for experimental purposes, up to those 8½ ft. diam. by 28 ft. long.

APPROXIMATE CAPACITIES AND MATERIAL USED IN CONSTRUCTION

Size of Furnace, Inches.	Weight of Iron Work.	Number Fire Brick.	Number Common Brick.
32 in. by 60 in.	3,600 lbs.	....	....
6 ft. by 12 ft......	17,800 "	1,300	18,000
7 ft. by 18 ft......	30,000 "	1,700	20,000
8½ ft. by 18½ ft...	52,000 "	2,800	25,000
8½ ft. by 28 ft....	69,000 "	3,300	27,000



The White-Howell Roasting Furnace

Plate 41

THE WHITE-HOWELL ROASTING FURNACE

Plate 41 illustrates the well-known White-Howell Roasting Furnace. It consists of a long telescopic shaped iron cylinder, made in sections to facilitate transportation, slightly inclined, supported on friction rollers and revolved between a stationary fire-box and a flue. That portion of the cylinder nearer the fire has a larger external diameter than the part next to the flue, but it is lined with fire-brick to make its internal diameter the same as that of the smaller part, which although unlined, stands the heat very well. Projecting fire-brick arranged spirally in the brick-lined portion assist in oxidation by raising and showering the ore through flame, which it will be understood passes directly through the cylinder, and for the same purpose the unlined part is provided with cast-iron shelves.

The furnace is fed at the upper end with dry pulp by means of a suitable screw feeder, and the pulp makes its way automatically toward the lower end of the furnace where it passes out, dropping between the end of the cylinder and the fire-box into a vault.

Sometimes an auxiliary fire-box is placed at the flue end of the roaster (see Plate 41) for roasting the flue-dust as it passes, suspended in the air, into the dust chamber.

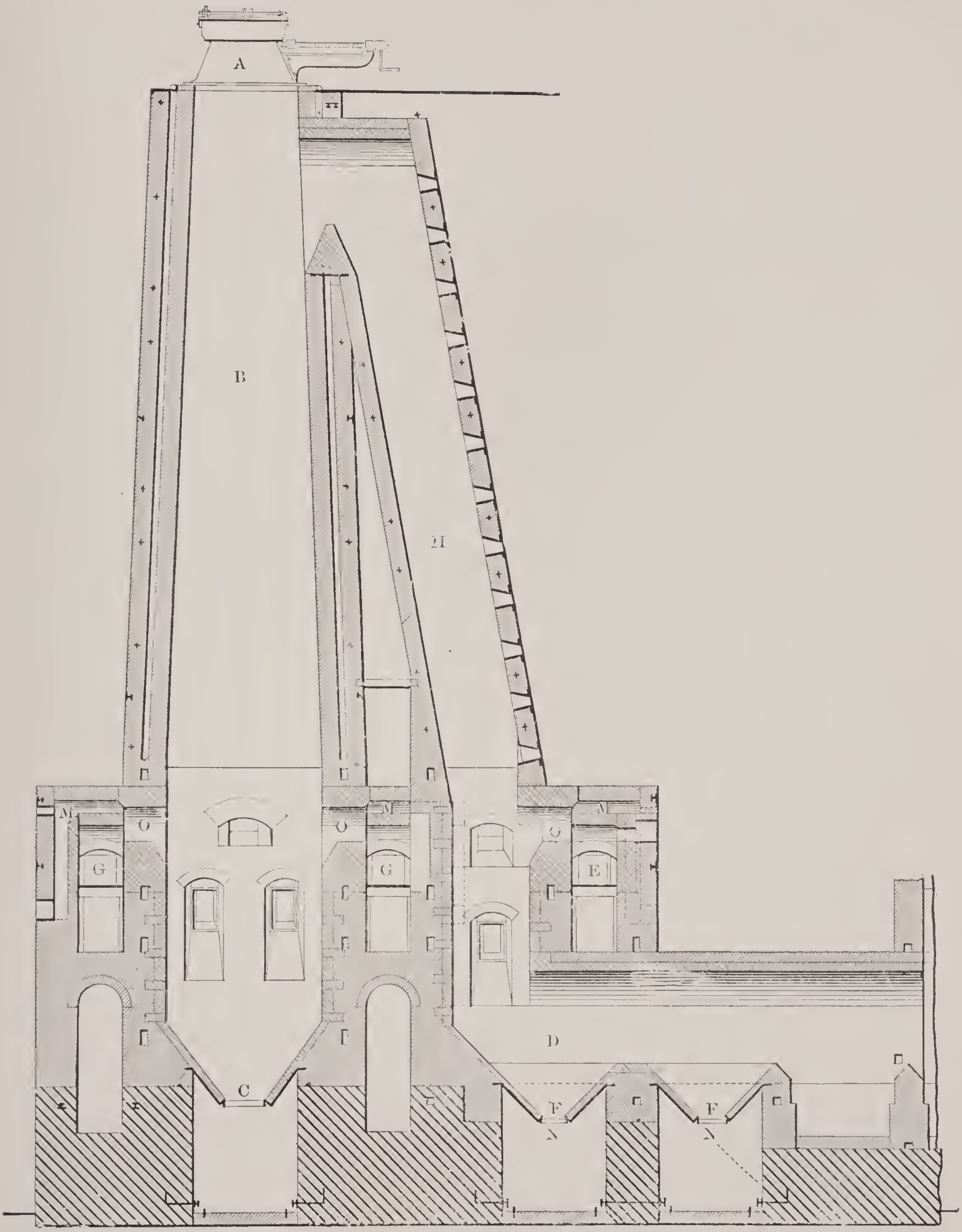
The White-Howell Roaster has given excellent satisfaction for many years, its principal use having been for chloridizing silver ores for amalgamation, or leaching with sodium hyposulphite.

For these roasters we furnish complete iron work, consisting of cast-iron cylinder (in sections with bolts), truck wheels, shafts, bearings, frames, guide stands and rollers, gears, pulleys, end plates, fire doors, discharge doors, grates, binders, tie rods, feed-hopper, flue doors, etc.

SIZES, WEIGHTS AND CAPACITIES OF WHITE-HOWELL ROASTERS

Diameter.	Length, Feet.	Capacity in Tons.	Weight of Iron Work, Lbs.	Fire Brick Required.	Common Brick Required.
31 in. by 41 in.	23	15-20	25,500	1,900	22,000
52 in. by 62 in.	27	30-50	43,500	2,700	28,000

Plate 144



Stetefeldt Roasting Furnace

THE STETEFELDT ROASTING FURNACE

The Stetefeldt Roasting Furnace consists of a vertical brick shaft some 25 feet high, having a fire-box near the bottom and a flue-opening near the top; by means of a screen feeder, worked automatically, pulverized ore is continually sifted into the shaft and, in falling through the heated air, which takes but a few seconds, it is roasted.

There is also a fire-box placed at the bottom of the descending flue for roasting the flue-dust, which may amount to as much as 30 per cent. of the ore.

We are prepared to furnish the iron work for this type of roaster in three sizes:

No. 1.	Capacity	10 to 20	tons	per	24	hours.
2.	"	20 to 40	"	"	24	"
3.	"	40 to 80	"	"	24	"

MUFFLE FURNACES

Muffle furnaces are closed reverberatories so constructed that the products of combustion from the fuel are not allowed to mix with the gases evolved from the ore. Such a furnace may consist of one long continuous muffle or several muffles arranged in tiers one above the other in one furnace construction.

Muffle furnaces are chiefly used for roasting iron pyrites and zinc blende when it is desired to collect the sulphurous acid fumes, free from mixture with fuel gases and from excess of air, for the manufacture of sulphuric acid.

Plate 779 shows a cross-section through a Brown Muffle Furnace which was recently shipped to a customer in Europe. The hearth is 10 x 150 ft., arranged to be heated by "producer" gas. The large spaces directly beneath the hearth are combustion chambers where the fuel gases are burnt. Double doors at either end of the hearth prevent excessive admission of air into the hearth when the stirrer carriages pass in and out, the distance between the doors being such that one is opened and shut before the other is opened; in other respects the furnace is like the Brown Straight Roaster (Plate 781).

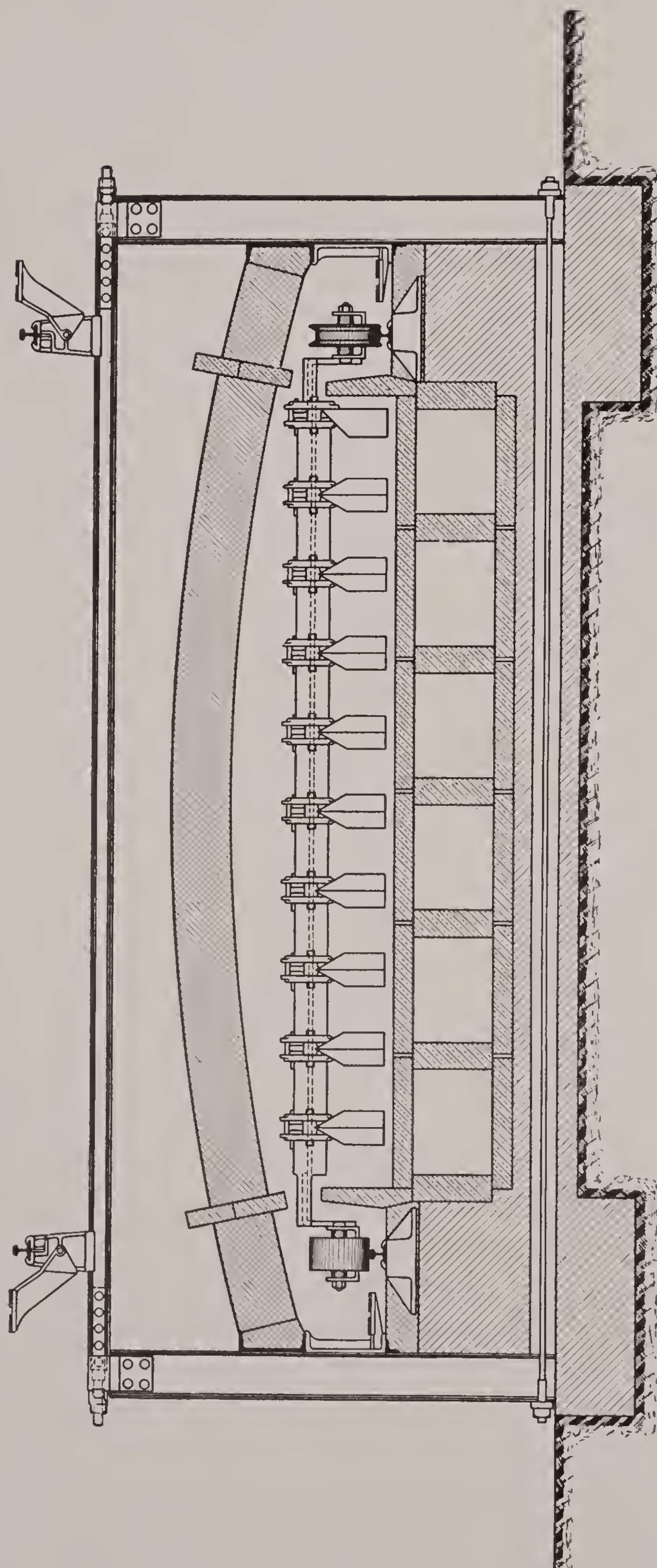


Plate 779

Section

The Brown Muffle Roasting Furnace

Smelting

Methods
Furnaces

Blast Furnaces for Lead Ores
Blast Furnaces for Copper Ores
Reverberatory Smelting Furnaces
Accessories
Plants

SMELTING

To melt or fuse ore for the purpose of separating the metal or its sulphur compound from its gangue is called smelting. It consists in subjecting ores mixed with suitable fluxes to the action of intense heat, whereby the materials become fluid, the gangue of the ore combining with the fluxes to form a usually worthless slag or scoria, while the valuable portions combine together to form an alloy or matte, the separation taking place while the materials are in the molten condition by difference in their specific gravity.

Smelting is performed either in a blast furnace where the fuel (coke or charcoal) is mixed with the ore and fluxes, or in a reverberatory where it is burnt in a separate fire-box.

Smelting as we will consider it, relates to the treatment of gold, silver, copper and lead ores in blast furnaces, and it is covered by the following modifications:

1. Smelting to silver-lead bullion.
2. Smelting to copper-matte in the case of copper sulphide, or to black copper should the ores be oxides and carbonates.
3. Compromise pyritic smelting.
4. Iron-matte smelting.

The processes are, in a measure, igneous concentration, the separation of the worthless gangue from the valuable portion of the ore by oxidation and reduction in the presence of heat aided by suitable fluxes and fuel, and taking advantage of the difference in specific gravity of the materials.

For smelting, we must have ores (or a mixture) of suitable composition, and for its successful operation a sufficient percentage of lead, copper, or iron pyrites must be present.

Ordinarily for lead smelting the charge should contain from 12 to 18 per cent. of lead, and for matte smelting not less than 15 per cent. of matte should be produced.

Large smelting companies buy ores of all kinds, even those containing neither lead nor copper, afterward combining them with copper or lead ores, as the case may be, in such proportion as to produce a charge containing the proper amount of copper or lead.

Often ores to be smelted are previously roasted in order to minimize and therefore concentrate as much as possible the matte production.

In "pyritic" smelting no previous roasting is performed.

The slags produced in smelting consist, to the extent of about 90 per cent., of silica, ferrous oxide and lime, the other 10 per cent. being alumina, oxide of zinc, etc.; hence it will be seen that for smelting not only a proper percentage of lead or copper must be present, but also silica, iron and lime.

As the metals or their compounds to be recovered usually have a quartz gangue, limestone and iron ore are usually the fluxes required, and they should be found in a locality convenient to the smelter.

The fuel used in blast furnaces is coke, charcoal, or a mixture of the two, in amounts equal to about one-sixth of the weight of the ore and fluxes: In reverberatories, wood, coal, gas or oil is used.

All ores of copper or lead can be smelted, and when they contain too low a percentage of these metals to be smelted directly, they can be brought up to the standard of smelting ores, by previous concentration.

Ores containing any considerable quantity of sulphur should be previously roasted, as they will then require less iron flux and the capacity of the furnace will be correspondingly increased. Such ores can often be roasted without previous crushing, in heaps, stalls, or kilns, at small expense; after which they can be satisfactorily smelted. The oxides and sulphides re-act upon each other in the furnace with the production of metallic copper or lead and sulphurous acid gas.

Success in smelting (outside of smelting carbonates of lead and copper, which are very simple operations) depends upon a proper mixture of ores, proper roasting and adjustment of fluxes. The mere presence of a little galena in a camp is not sufficient to justify the erection of a smelting plant. For good results, a mixture of ores is usually needed, high grade silver and gold ores to bring up the value of the bullion; ores with lime gangue to neutralize ores in quartz so as to avoid if possible melting barren fluxes; reasonable transportation to market of bullion, cheap fuel, and many smaller considerations, important in influencing commercial results.

The cost of smelting varies greatly according to the character of the ore, size of the furnace, arrangement, locality, etc.

Smelting practically saves all the gold, 95 per cent. of the silver and 90 per cent. of the lead or copper.

Blast furnace slags do not usually contain more than ¾ of one per cent. of lead or copper and ½ oz. silver to the ton.

The type of slag to make and the percentage of valuable metals contained therein is more of a commercial than a metallurgical problem.

Not an unimportant advantage of smelting is, that all ores in proper combination can be treated by this process. To conduct the process successfully, high metallurgical ability and experience are required, for it is much more complicated than other metallurgical processes, such as amalgamation, leaching, etc.

FRASER & CHALMERS EMPLOY EXPERIENCED PROFESSIONAL MEN IN ALL THEIR DEPARTMENTS, AND WHEN ORDERS ARE RECEIVED THEY ARE FOLLOWED THROUGH THE DRAWING ROOM AND SHOPS BY THE EXPERT TO WHOSE DEPARTMENT THEY BELONG, THUS INSURING ACCURATE AND PROMPT ATTENTION.

PYRITIC SMELTING

Theoretically, pyritic smelting is the process of smelting sulphide ores in a blast furnace without the aid of carbonaceous fuel, heat for smelting being furnished by the combustion of the sulphur in the ore.

Practically, some advantage is taken of this source of heat aided by a moderately hot blast, and the percentage of carbonaceous fuel has been thereby much reduced, though not altogether avoided. Dr. Peters calls this modification and practical use of the process "compromise pyritic smelting". It may be defined as smelting with from 3 to 4 per cent. of coke, using a hot blast, low pressure and a large volume of air. Excellent results are obtained with a blast heated to only 400° Fahr., though as hot as 1000° would be preferable.

Any ordinary copper matting furnace is suitable for this work; it should have high jackets, preferably of steel, be provided with a brick or iron hood, the blast should be trapped, and the slag and matte should discharge continuously into a forehearth.

By this process as high a concentration as 13 into 1 may often be obtained.

This process has been employed with only enough copper present—about one-half of 1 per cent—to clean the slag. The presence of some copper in the ore is essential, otherwise there will be considerable loss of gold and silver in the slag.

Compromise pyritic smelting is also successfully applied to smelting copper ores containing as little as 5 per cent of copper,—a 30 per cent. copper matte being produced. From 2½ to 3 per cent. of coke is used and a blast heated to 400° Fahr.; the matte is run through again, producing a 50 to 60 per cent. matte. The best result so far in the direction of pyritic smelting is the work of Mr. Robert Sticht, General Manager of the Mt. Lyell Mining & Railway Co., Tasmania.

IRON MATTE SMELTING

This process is often classed under pyritic smelting. It consists in smelting dry sulphide ores which should contain not less than 15 per cent. of iron pyrites, with from 10 to 20 per cent. of coke, a cold blast being used. As in compromise pyritic smelting, to obtain clean slag some little copper must be present.

METHOD OF HEATING THE BLAST

The blast is best heated by causing it to pass through a series of large cast-iron "U" shaped pipes contained in a brick structure, the tubes being heated from fire-boxes in which wood is burned. Should the blast be heated to a high temperature, the blast pipe and bustle pipe should be lined with brick.

Attempts have been made to heat the blast by means of hot slag, also by air jackets; the former method requires considerable machinery such as hydraulic mechanism for propelling the pots of slag through a chamber or tunnel, and in the latter, there is not sufficient superficial heating area.

It has been suggested that oil be burned in a chamber placed between the blower and the furnace, and that the blast pass through the chamber, being thereby heated. We think that the weakening of the effectiveness of the air by mixing it with the products of combustion from the oil much more than counterbalances any advantages sought to be gained by this method of heating.

S. E. BRETHERTON'S PATENTED SYSTEM FOR HEATING BLAST

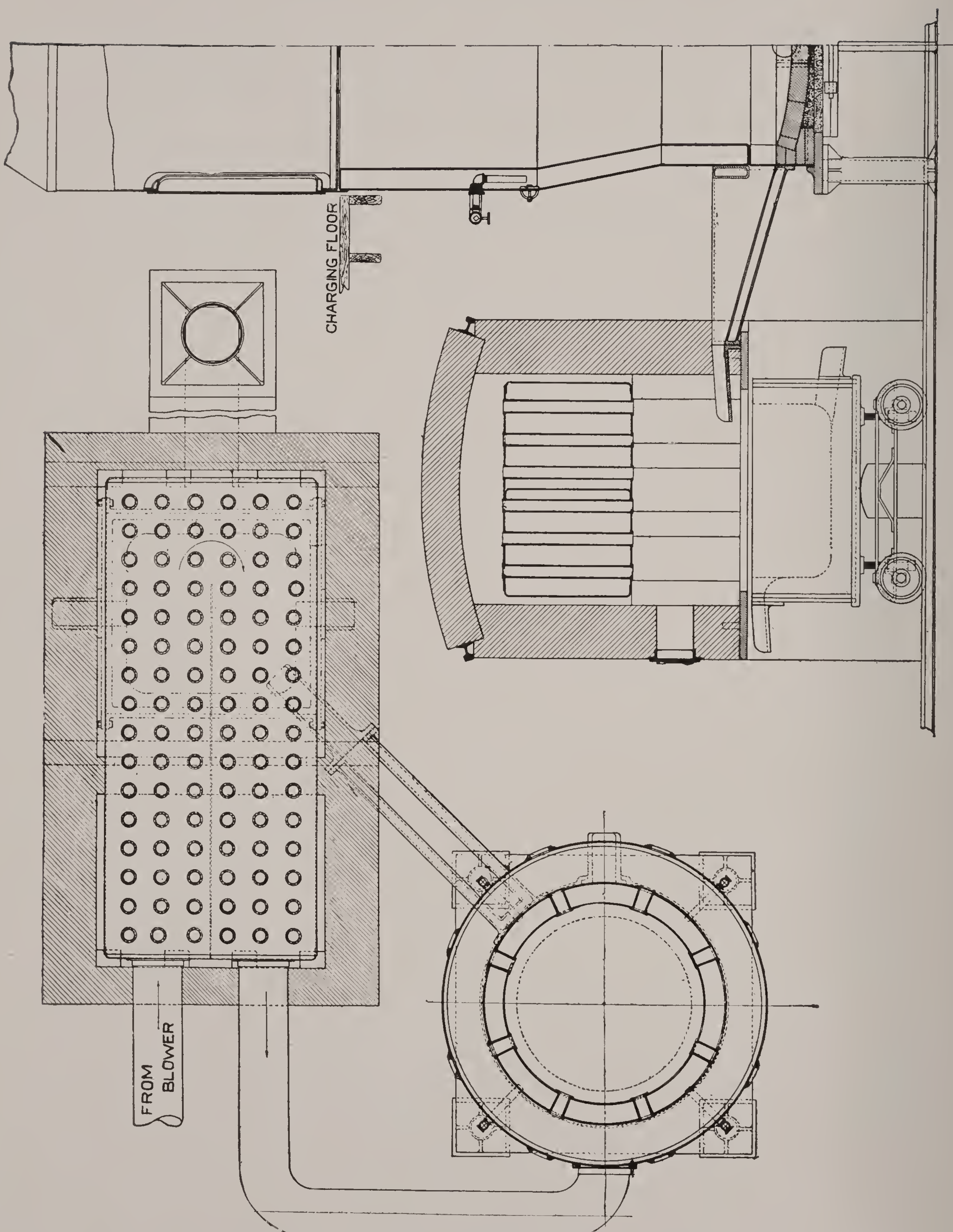
Mr. S. E. Bretherton, of Silver City, New Mexico, has recently introduced a method for heating the blast by means of heat radiated from blast-furnace slag, and by this means he states that he has succeeded in largely reducing the percentage of coke and very materially increasing the capacity of the furnace.

Plates 931 and 932 show the construction and arrangement of the apparatus which he is using. The furnace is 48 inches in diameter, and has one single-welded steel jacket 9½ ft. high (plate 931 shows this jacket). The blast is trapped, and the slag and matte flow continuously over a jacketed spout into a forehearth or settler placed within a brick chamber.

The forehearth is large, compared with the size of the furnace, to permit the slag to separate from the matte. The slag flows from the forehearth continuously, and the matte is tapped at intervals from the bottom spout.

Placed over the forehearth is a large rectangular sheet-iron box which has vertical flues passing through it, the larger portion of the box being directly over the forehearth. The heat radiated from the molten slag passes upward through those flues situated directly over the forehearth, then downward through the others, after which it passes under and around the forehearth and out through the chimney, as indicated by arrows.

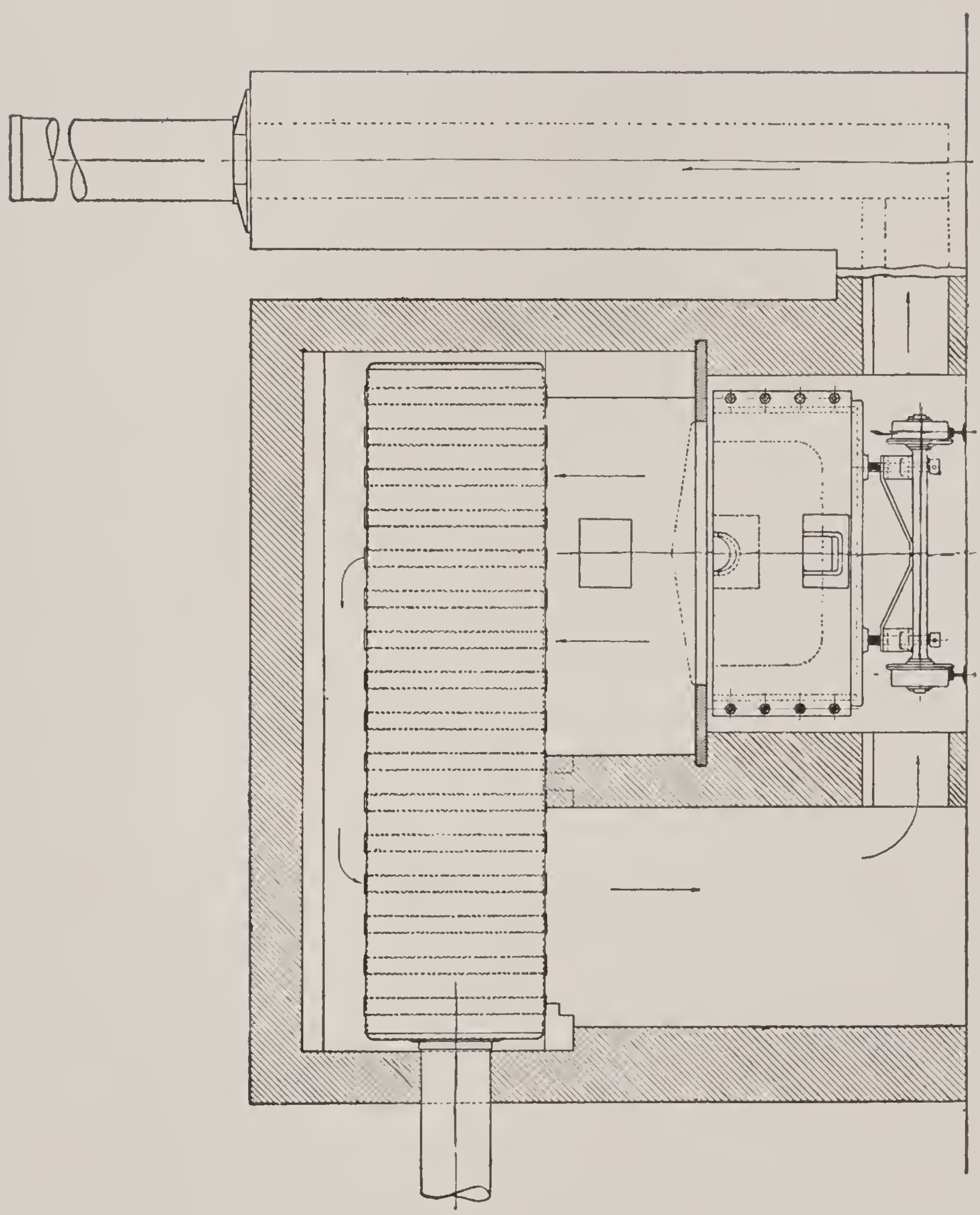
The rectangular box is placed between the blower and the wind-box of the furnace and the blast is made to traverse twice through the box, by means of a vertical diaphragm contained in the same.



S. E. Bretherton's Patented System for Heating Blast.

Plate 931.

Plate 932



S. E. Bretherton's Patented System for Heating Blast

The small door in the brick wall over the forehearth is for the introduction of sticks of wood for keeping a small fire on the surface of the slag; this is sometimes desirable, and assists in heating the blast.

By means of this simple apparatus Mr. Bretherton reports that he is enabled to heat the blast to from 500° to 600° Fahr., and thereby make a saving of from one-half to two-thirds of the amount of coke required when the furnace is run in the ordinary way with cold blast, and also increases the capacity of the furnace more than 60 per cent. His furnace formerly smelted 50 tons of ore, it now smelts 80 tons; he formerly used from 10 to 15 per cent. of coke, he now uses from 3 to 8 per cent., the ore being practically the same in both cases.

This valuable blast furnace accessory can be applied to any copper, lead or iron matte smelting furnace which is large enough to yield a continuous flow of slag.

Parties who are engaged in smelting and wish to save fuel and increase the capacity of their furnaces, would do well to write to us for further particulars and estimates.

BLAST FURNACES

BLAST FURNACES FOR LEAD ORES

The general form of the blast furnace used for smelting silver-lead ores has undergone but little change during the past few years, improvements having been only in minor details and in the direction of simplicity and durability.

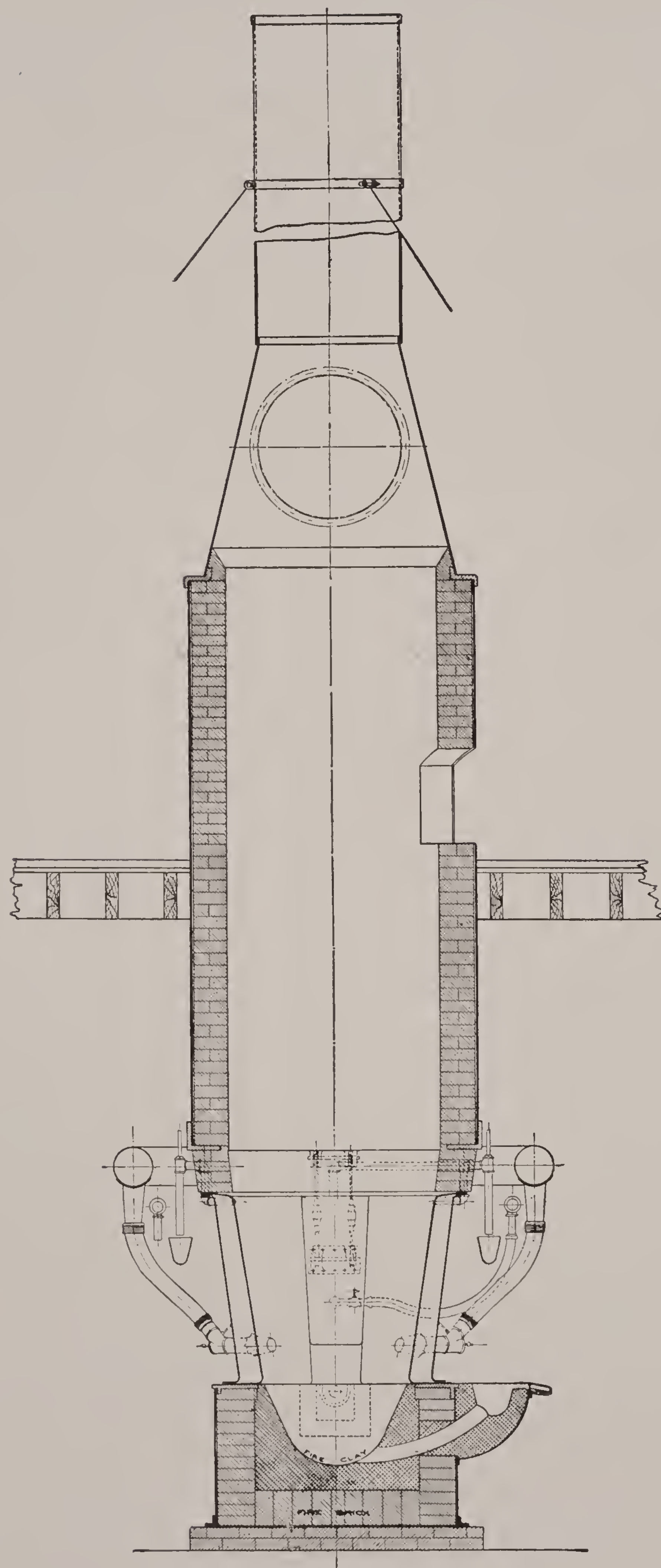
The principal changes have been the extensive substitution of sheet-steel jackets and structural-steel mantle or supporting-frame, for such parts as were formerly made of cast iron. In fact, in addition to the four columns used for supporting the brick shaft, very little cast iron enters into the construction of the modern blast furnace.

This change in construction makes the first cost of the furnace greater, but this is more than compensated for by its increased durability (which is especially important in remote localities) and by decreased weight.

In general, the blast furnace for lead ores may be described as a rectangular brick shaft bound with iron, resting on a steel mantle-frame supported at the four corners by cast-iron columns. Below this shaft is the smelting zone, which has a bosh surrounded by water jackets made of boiler-steel plates or of cast iron; the side jackets near the bottom have openings for tuyeres; the jackets rest on a curb of fire-brick encased in steel plates, and in the center of this curb is a large cavity called an internal crucible from which the lead is removed through what is known as "Arent's Syphon Tap".

Round water-jacketed furnaces are employed when smelting operations are conducted on a small scale, in refineries for working up by-products, for jewelers' sweepings and in experimental laboratories.

Plate 875



Vertical Sectional View

Steel Water-Jacketed Blast Furnace For Lead Ores Round Type

To avoid confusion in illustrating the details of the furnace, the cast-iron supporting columns have been omitted from the cut

STANDARD 36-INCH STEEL WATER-JACKETED BLAST FURNACE FOR LEAD ORES (Round Type)

Plate 875 illustrates a vertical sectional view of our standard design for round lead furnaces which we make in several sizes—from 20 inches diameter upwards. The curb is made of tank steel plates, the jackets of boiler steel ; the brick shaft is surrounded with a steel casing.

Plate 796 is a photo-reproduction showing the curb and jackets of the same furnace. The projection on the left is the lead-well which, as well as the curb, should be lined with fire-brick.

As the smelting capacity of these round furnaces is limited by their diameter at the tuyeres, and as it has been found by experience that this diameter cannot exceed 48 inches, recourse must be had to oblong rectangular furnaces when smelting to any considerable extent.

THE SIZE OF A FURNACE is determined by the internal area at the tuyere level. With oblong furnaces the width varies from 30 to 42 inches, and the length from 60 to 160 inches. Furnaces have been built 60 inches wide, but the tuyere pipes were then pushed into the furnace 6 inches beyond the inner wall of the jackets, which reduced the actual width between the tuyeres to 48 inches. No advantage was gained by thrusting the tuyere pipes (which had to be water-jacketed) into the charge, and the construction was abandoned.

As the width of the furnace is increased, a proportionately higher blast pressure is required, as there is more material to force the air through ; there should also be a corresponding increase in the height of the shaft.

The distance from the tuyeres to the feed-floor is designated as the height of the furnace, and this may vary from 12 to 18 feet.

Tuyeres are placed on the sides only, one at the back end being seldom used; as a rule, there should be one 3-inch tuyere or its equivalent for every 2 sq. ft. of furnace area at the tuyere level.

The lower part of the brick shaft is made thicker than formerly, in order to reduce radiation of heat and lessen fuel consumption. The shaft is either lined with, or built entirely of, fire-brick.

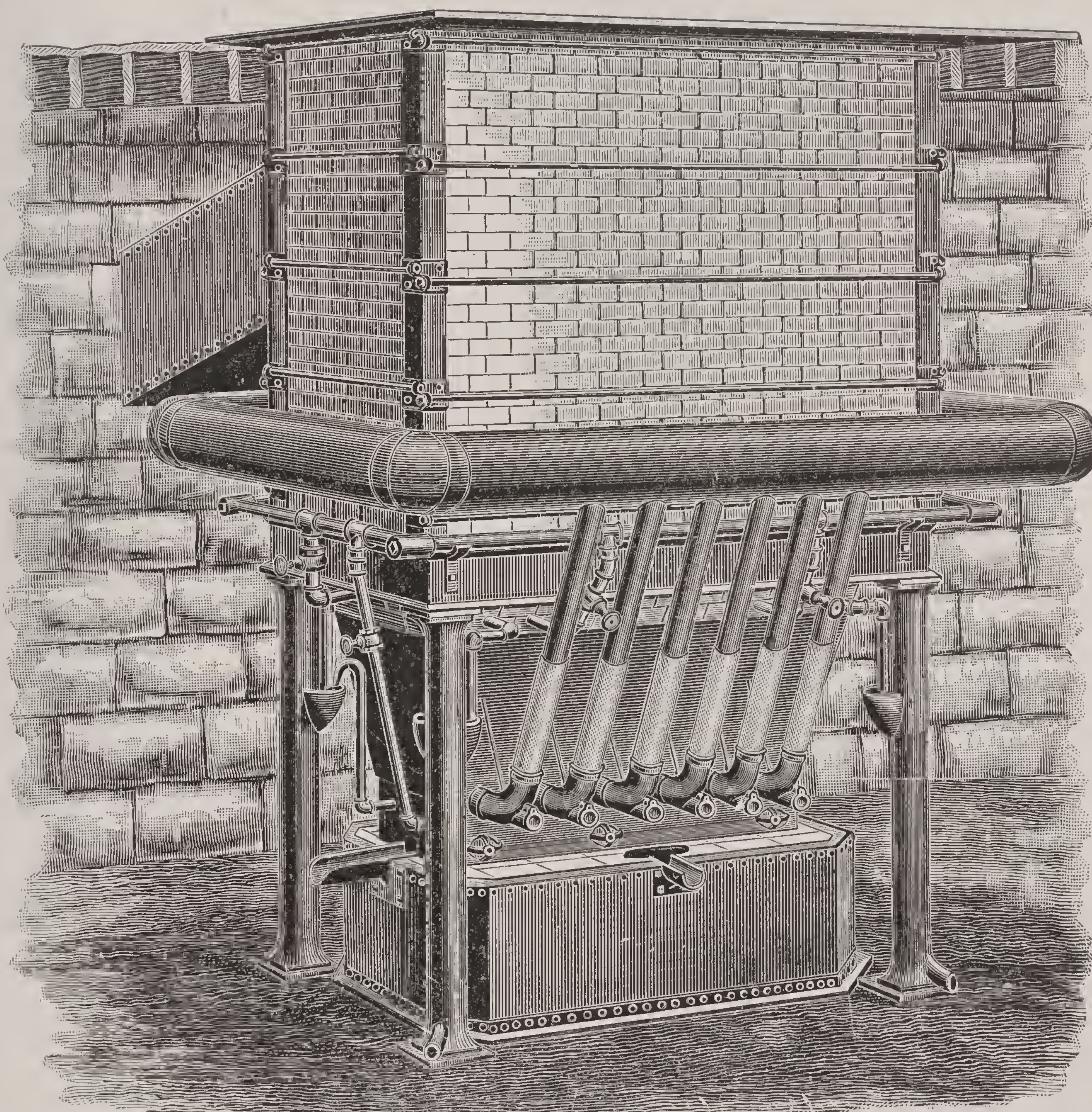
BLAST FURNACE FOR LEAD ORES (Rectangular Type)

Plate 775 is an illustration of a modern blast furnace for silver-lead ores. The jackets are of flange steel, the seams being welded together; the curb is of tank steel, the mantle-frame of structural steel. Pockets cast on the columns receive the overflow water from the jackets. The only cast-iron parts entering into the construction are the columns and spouts.

As a rule, modern lead furnaces do not extend above the feed-floor, though lately we have filled orders for some in which the shaft extends above the feed-floor several feet, where it is capped with a steel hood from which extends a steel stack and a downtake.

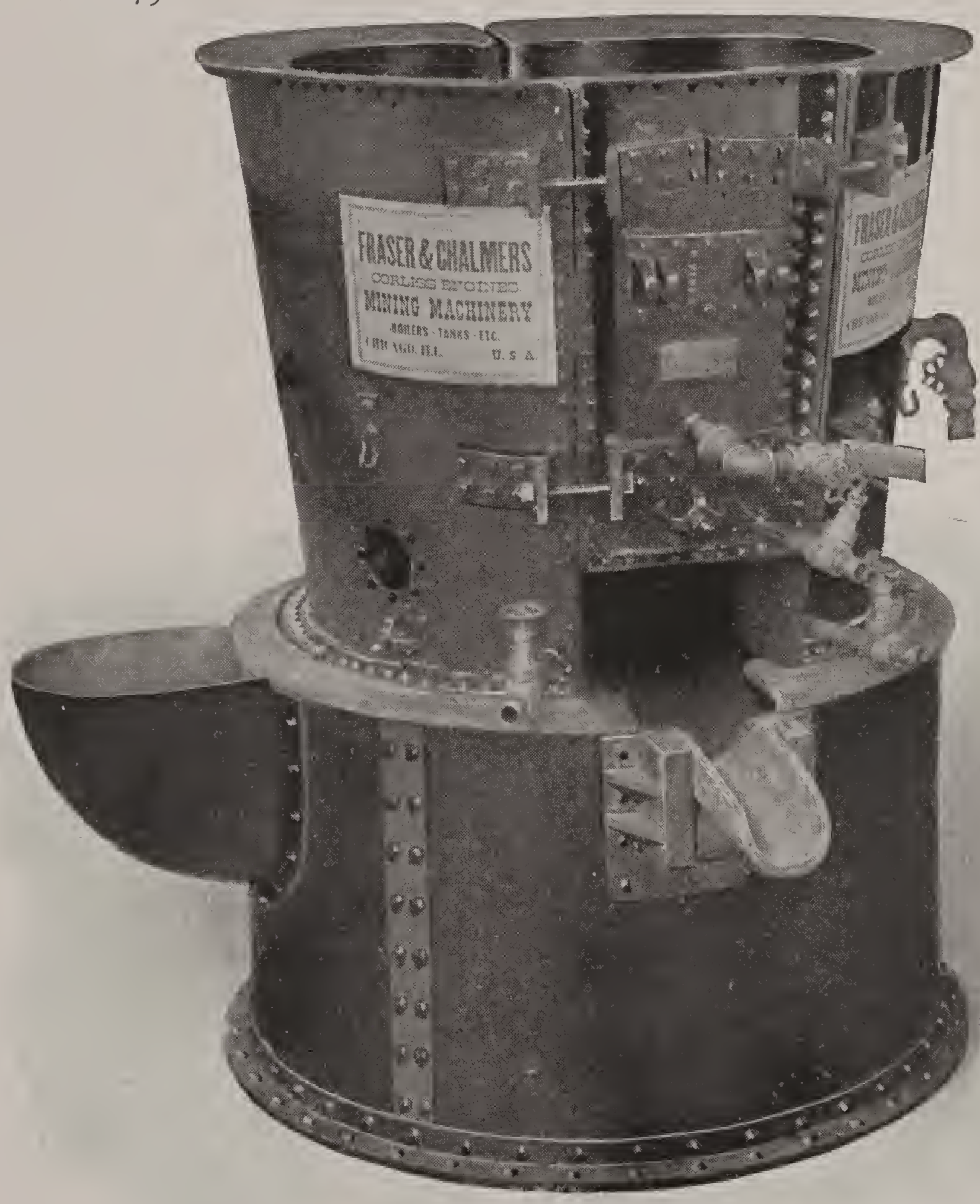
In those furnaces which do not extend above the feed-floor the fumes are conducted into the dust chamber through an iron or brick flue, which starts from the furnace shaft just below the feed-floor and extends in a downwardly inclined direction into the dust chamber, the latter being usually built in back of the retaining wall, this wall forming the front wall of the dust chamber.

Plate 775



Steel Water=Jacketed Blast Furnace for Lead Ores
Rectangular Type

Plate 796



Curb and Jackets of Standard 36-inch Steel Water-Jacketed Blast Furnace for Lead Ores (Round Type)

(See page 67.)

BLAST FURNACES FOR COPPER ORES

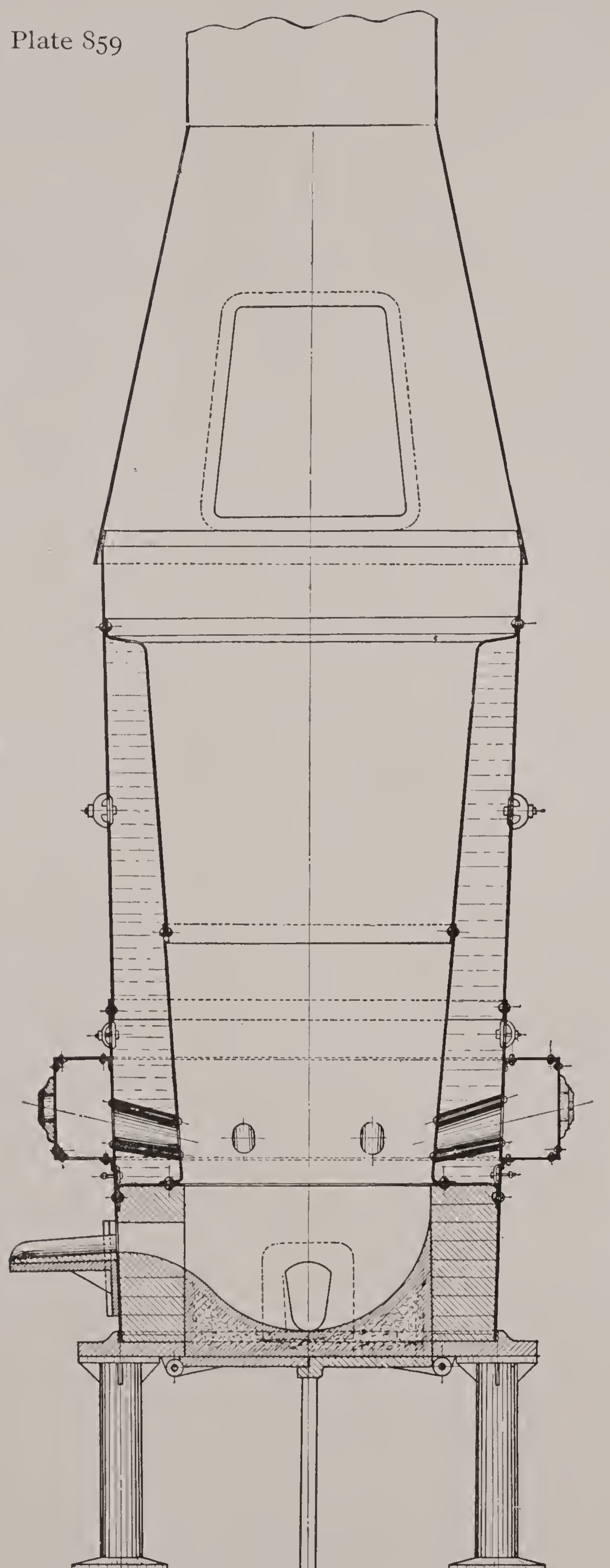
These furnaces differ considerably from those used for lead ores. Small ones, up to 48 inches in diameter, are made round; larger ones, oval and rectangular.

The jackets are made of steel plates and are of greater height than those used for lead. The internal crucible is either very shallow or dispensed with altogether. The curb is low and rests upon a cast-iron base-plate supported on columns. Plate 80 represents an exterior view of our improved round blast furnace, a style extensively used for smelting copper ores and for concentrating matte. Plate 859 is a vertical sectional view of the same furnace.

The jacket is made of the best flange steel, the sheets being either riveted or welded together, as preferred (see "Water Jackets"), and fitted with bronze tuyeres. The jacket is surrounded with a removable wind-box; to this the blast pipe is connected, an arrangement insuring equal distribution of the blast to each tuyere and hence a perfect delivery of air to every part of the charge, thereby producing a very uniform melting zone. The tuyeres being entirely within the water space of the jacket, are protected from the action of the heat and consequently do not burn out or cause any trouble whatever. Peep-holes with removable mica coverings are placed in the wind-box opposite the tuyeres.

The curb is a sheet-steel casing made by prolonging the outer plate of the jacket some distance below the water space. The curb rests on a cast-iron base-plate which is supported on four columns. There is a large circular opening in the center of the base-plate, closed by two drop doors

Plate 859



Vertical Sectional View

Steel Water-Jacketed Blast Furnace For Copper Ores
Round Type

Steel Water=Jacketed Blast Furnace for Copper Ores
Round Type

attached to its under side. The whole structure is complete with stack, inlet and outlet water pipes, slag and matte spouts, and the jackets are equipped with blow-off pipes and convenient hand-holes.

The furnace requires only a few fire-bricks to line the curb and base-plate after which "steep", a mixture of fire-clay and coke dust, is tamped in, and cut out to form a crucible of the proper shape.

These water-jacket furnaces are superior to all others in simplicity, strength, perfection of water circulation and capacity. They will run for months without a stoppage.

For low-grade pyritic ores the larger of these furnaces may be used without an internal crucible, the materials as soon as they reach the bottom in a molten condition being permitted to flow out of the furnace into an exterior crucible or forehearth mounted on wheels; this forehearth may be either water-jacketed, or lined with fire-brick.

We sell very many of these excellent furnaces, and by reason of their simple construction, facility with which they can be erected, durability and other desirable qualities, find great favor among our customers.

We might state here that the 36-inch furnace, which is the size most in demand, weighs 10,700 pounds, requires about 1,000 gals. of water per hour, and has a capacity of from 25 to 50 tons per 24 hours.

LARGE RECTANGULAR COPPER FURNACE.

Plates 923, 924 and 925 show vertical, end and side sectional elevations of a 44 x 168 in. steel water-jacketed blast-furnace for copper ores recently designed and built by Fraser & Chalmers.

This is the largest blast furnace for copper ores in existence, and embodies all the features of the best modern practice.

The curb, made of sheet steel, rests on a cast-iron base-plate built in sections for convenience in transportation ; the plate rests on eight short columns and has three openings covered by double drop doors.

To the center of one side of the curb is attached a tymp jacket and a jacketed spout, so constructed that the blast will be trapped and the matte and slag flow in a continuous stream over the spout into a capacious forehearth in which a separation between the materials mentioned will take place.

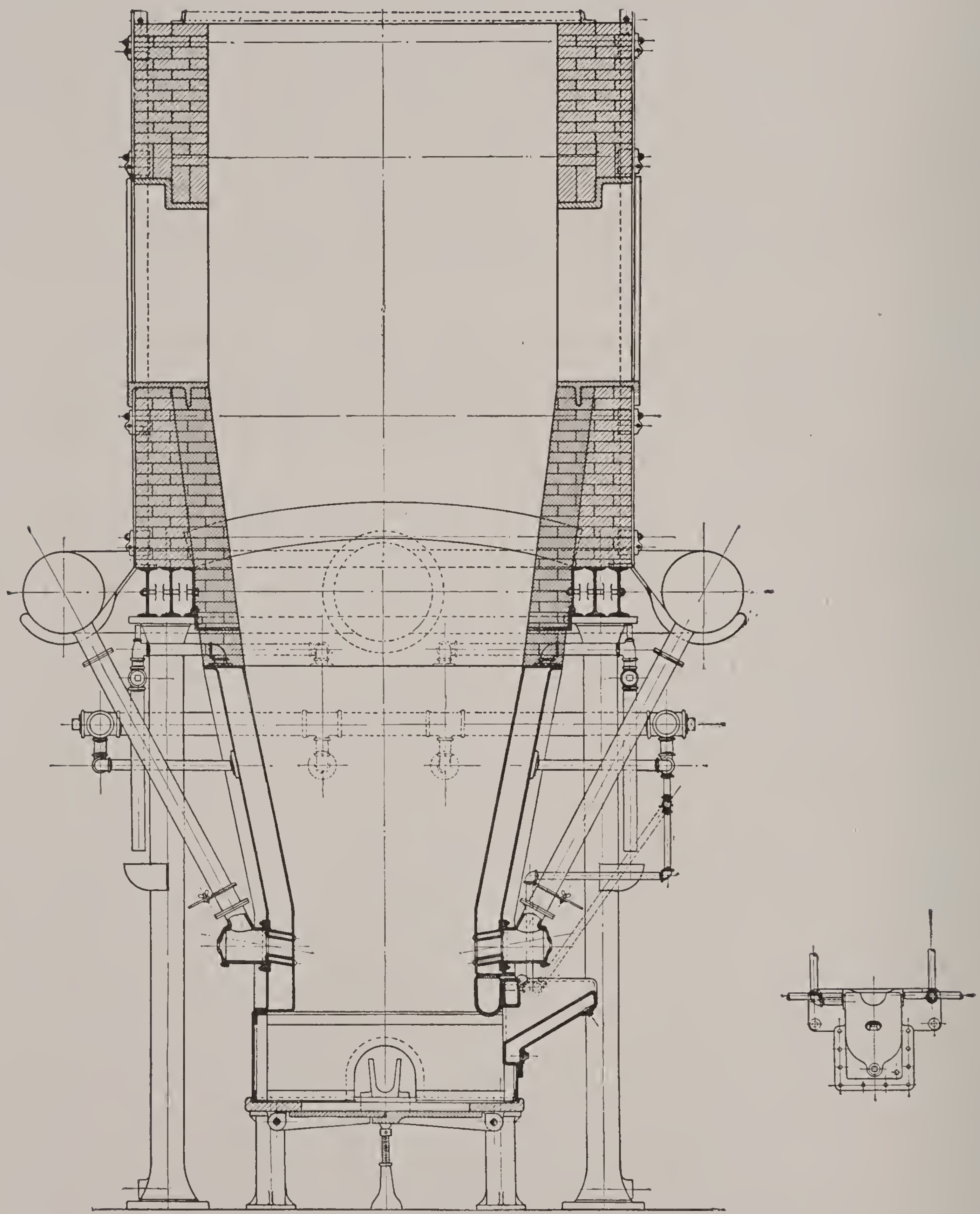
There are six side and two end jackets, made of flange steel; they are seven feet in height, the side jackets only, being "boshed".

There are twenty tuyeres, ten on each side, each having an independent tuyere-box fastened air tight to the jacket and rigidly connected with the bustle-pipe ; each tuyere pipe is fitted with a blast gate. By this construction all leakage is prevented and the amount of air entering each tuyere can be nicely regulated.

On each side of the furnace there are three charging doors which extend the full length of the furnace, so that wall accretions can be readily reached. The brick shaft extends eight feet above the charging floor, at which point it is surmounted by a steel hood, stack and downtake.

This furnace is not only of the most modern type, but it is of great durability and of very great capacity.

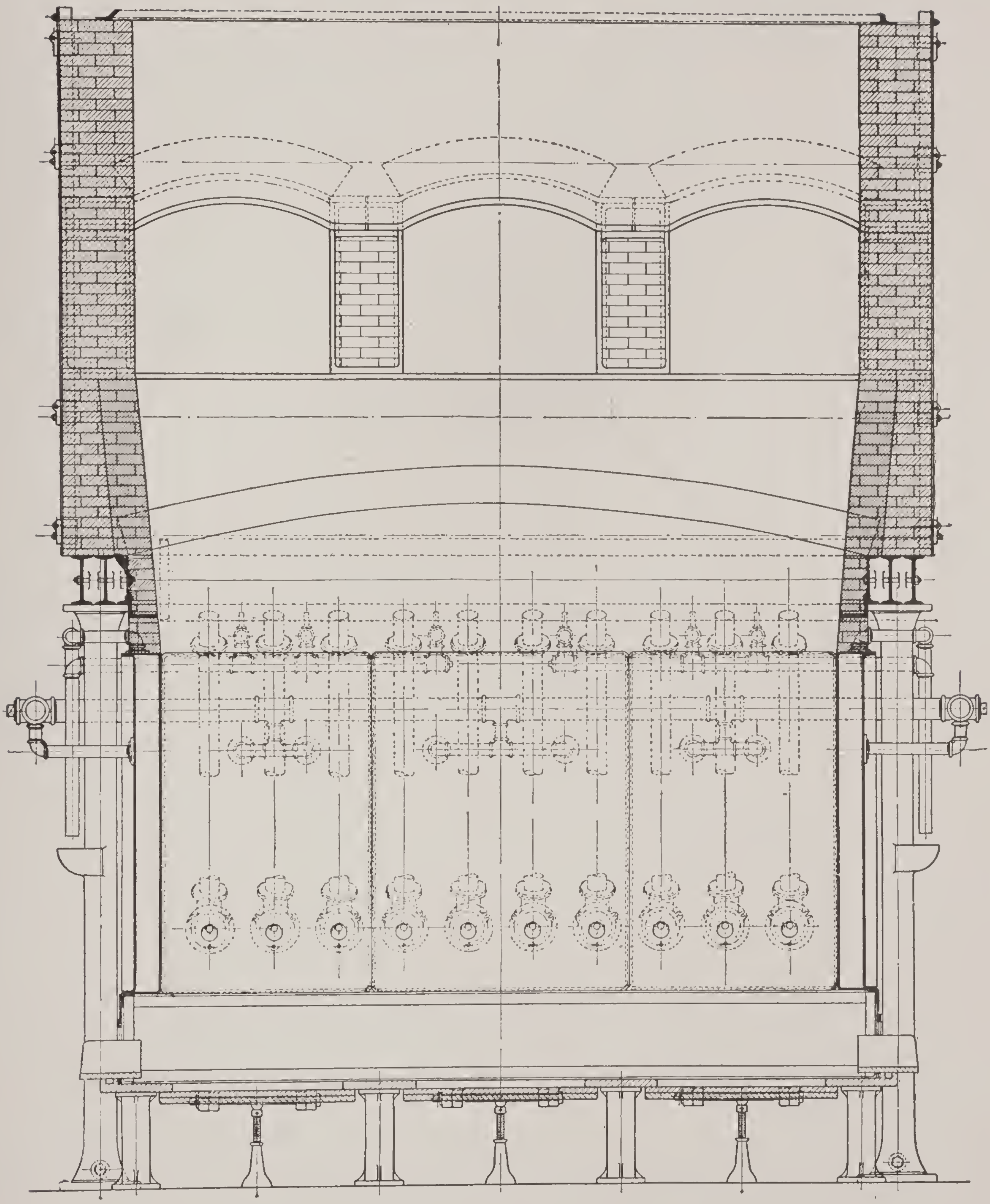
Plate 925



Large Steel Water-Jacketed Blast Furnace for Copper Ores
Rectangular Type

Sectional View of End

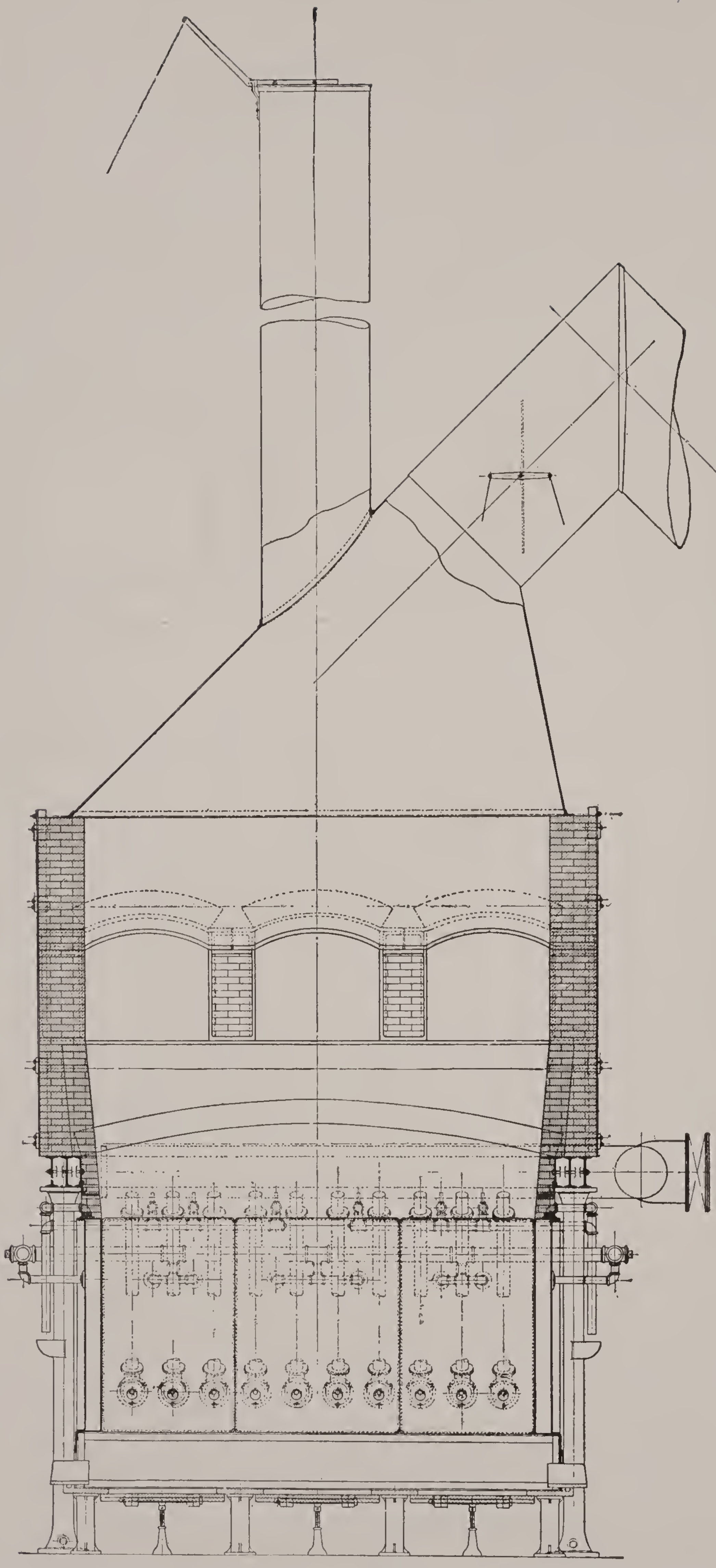
Plate 924



Large Steel Water-Jacketed Blast Furnace for Copper Ores

Rectangular Type

Sectional View of Side



Large Steel Water-Jacketed Blast Furnace for Copper Ores
Rectangular Type

Sectional View of Side, showing portion of Stack and Downtake

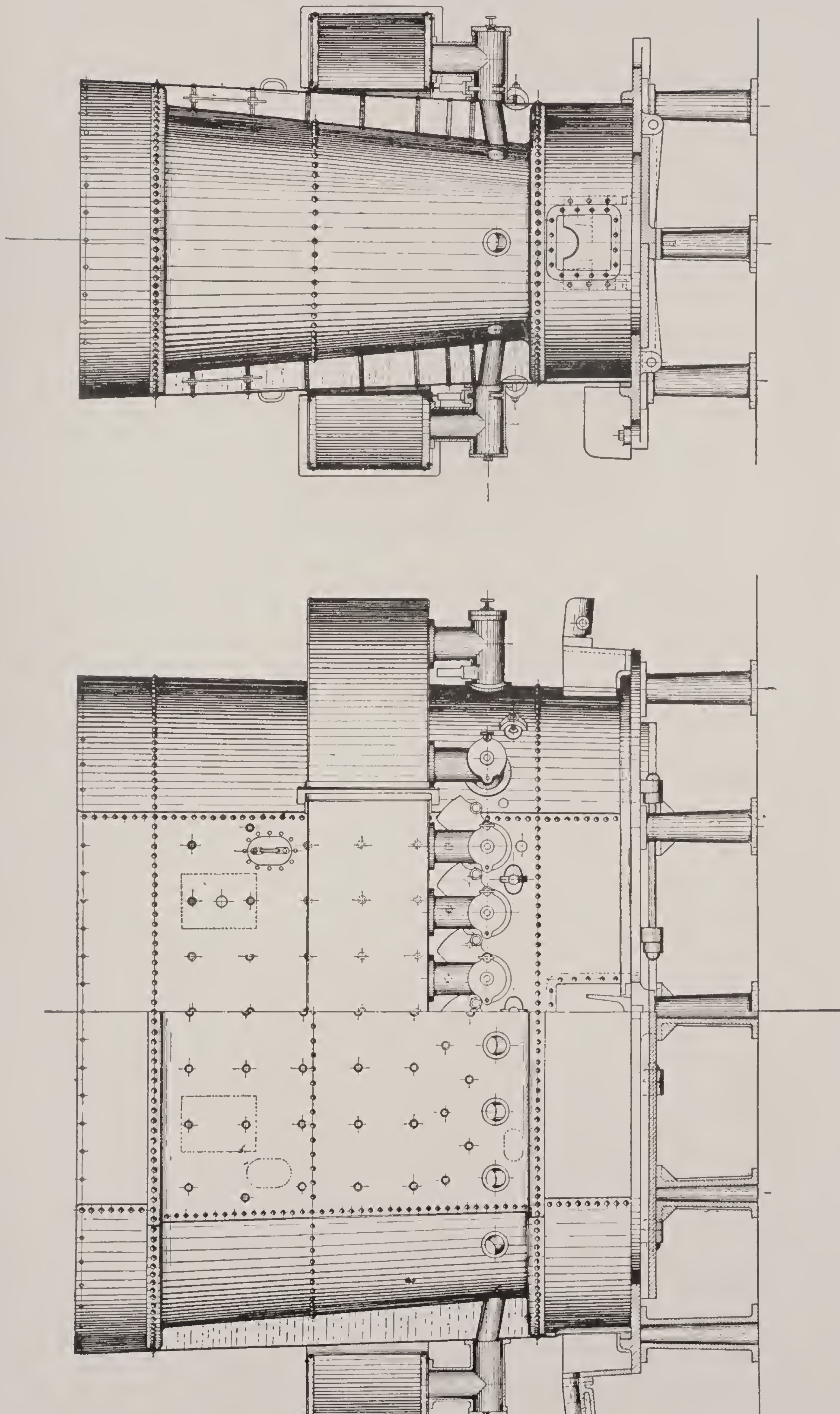


Plate 854

Large Steel Water-Jacketed Blast Furnace for Copper Ores
Oval Type

STEEL WATER-JACKET COPPER FURNACE

Oval Type

Plate 854 illustrates a 42 x 120 in. oval blast furnace used for matting copper ores. The jacket and curb are made in one piece, the jacketed portion being 6½ ft. high. The tuyere pipes are rigidly connected with the wind-box and the jacket, and each tuyere has an independent blast gate. The base-plate has two sets of drop doors. The feed-floor is on a line with the top of the jacket; above it, a brick shaft extends through the roof of the building, the shaft resting on a mantle frame supported on columns. It is of the latest design and embraces many desirable features.

WATER JACKETS

The smelting zone of the blast furnace is surrounded by water-cooled shells called "water jackets", made of cast-iron or steel plates; in the latter case the plates are flanged, the edges riveted or welded together, and so constructed that no seam is exposed to the fire.

Jackets have been made of cast steel, but they are difficult and expensive to make and, as their cost is not warranted by a proportionately increased durability over those of cast iron, their use has been abandoned.

The average height of jackets for lead furnaces is 42 inches, for copper furnaces from 4½ to 6 ft., while for iron matte smelting we have made them as high as 8 ft.

In rectangular furnaces the number of jackets depend upon their size—two end and two side jackets being the usual number except when the furnace is long; in this case the side jackets are made in two or three sections, for convenience in handling.

When it is desired to jacket a furnace to a considerable height, the jackets are often made in two tiers, which permits of making them smaller, consequently easier to handle.

A common method of "jacketing" cast-iron tapping jackets and spouts is to place in the mold a wrought iron pipe bent to suit the shape and pouring the molten iron around it.

We make a specialty of "SECTIONAL" steel jackets for mountain transportation, no piece exceeding 350 pounds in weight. When jackets are of such size and shape that they cannot be sectionalized, as is the case with round copper furnaces, we ship the plates cut, punched, rolled and nested, to be riveted together at the mine.

All jackets made by us are carefully tested before they leave our shops; they are provided with all necessary hand-holes, tuyere openings, lugs and binders, and connections for water piping.

ADVANTAGES OF STEEL JACKETS

Cast-iron jackets are still used for lead furnaces, but for copper and pyritic furnaces, steel ones are usually preferred. As before stated, the tendency is to abandon cast-iron construction in blast furnaces except for the columns which support the brick shaft. The substitution of steel gives increased strength with less material and minimizes the danger of breakage and delay incident to cast-iron construction. Lighter construction means less freight charges to pay—an important item in the installation of a smelter.

We know of some of our steel jackets which have been in constant service for five years and are as good now as the day the furnaces were "blown in".

On the other hand, a cast-iron jacket may crack the first day it is used; they are a constant source of annoyance and loss of time, and necessitate carrying a considerable stock of extras.

STEEL JACKETS FOR ROUND FURNACES

Plate 796 (page 68) represents the construction and general appearance of a set of steel jackets for a 36-in. round lead furnace, the set being made in three pieces and the seams riveted together; the jackets rest upon a curb made of tank steel.

Plate 794 shows a set of "sectional" steel jackets for a 36-in. furnace, made in seven pieces, for muleback transportation. The seams of these jackets are welded together by our new process, a process that has been endorsed by the leading smelting men.

Plate 859 shows the construction and general appearance of a single jacket for a 36-in. copper furnace; the plate shows the steel sheets riveted together, but we also make it with welded seams. This is a most popular furnace and admirably meets the requirements of parties who wish to smelt on a limited scale. There is scarcely an important copper camp in the United States or Mexico where one of them cannot be found in operation.

Plate 795 shows the welded steel jacket of a Bretherton 48-in. copper furnace. The jacket is made with a bosh and is 9½ ft. high by 5 ft. inside diameter at the top and 48 in. diameter at the tuyeres. The Silver City Reduction Company, of Silver City, New Mexico, has two such furnaces in blast. The following letter from their manager, Mr. S. E. Bretherton (from whose sketches we designed and built the furnaces) is convincing evidence that they have been eminently satisfactory:

SILVER CITY, NEW MEXICO, Feb. 27, 1899.

Gentlemen: In reply to yours of the 22d inst., asking about the Fraser & Chalmers Welded Water Jacket Blast Furnace, will state that we have had one of them in use three years, and another more than two years, where we have the worst water for forming scale I ever knew. We wash the scale out at the bottom of the furnace about every thirty days, and to-day the furnaces are both as good as the day we purchased them, and so far we have not had to purchase a fire-brick or pound of fire-clay for repairs, on account of their shape, and the water jacket being as high as the feed-floor.

We are now smelting with one of the round furnaces, doing very clean work, 60 to 80 tons of ore and some flux, not including the fuel we are using.

Hoping the above answer to your question will be satisfactory,

Yours truly,

SILVER CITY REDUCTION COMPANY,

S. E. BRETHERTON.

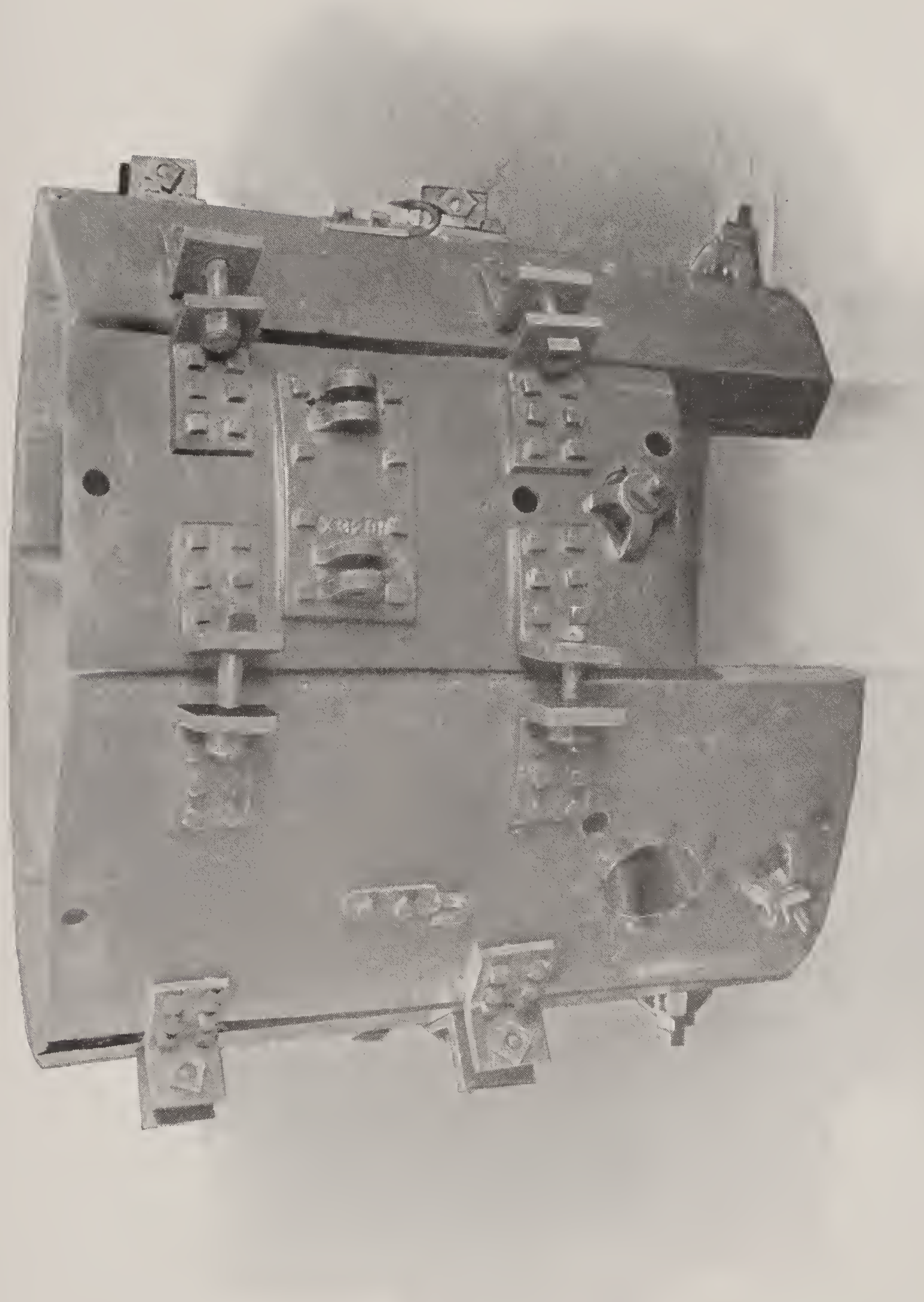
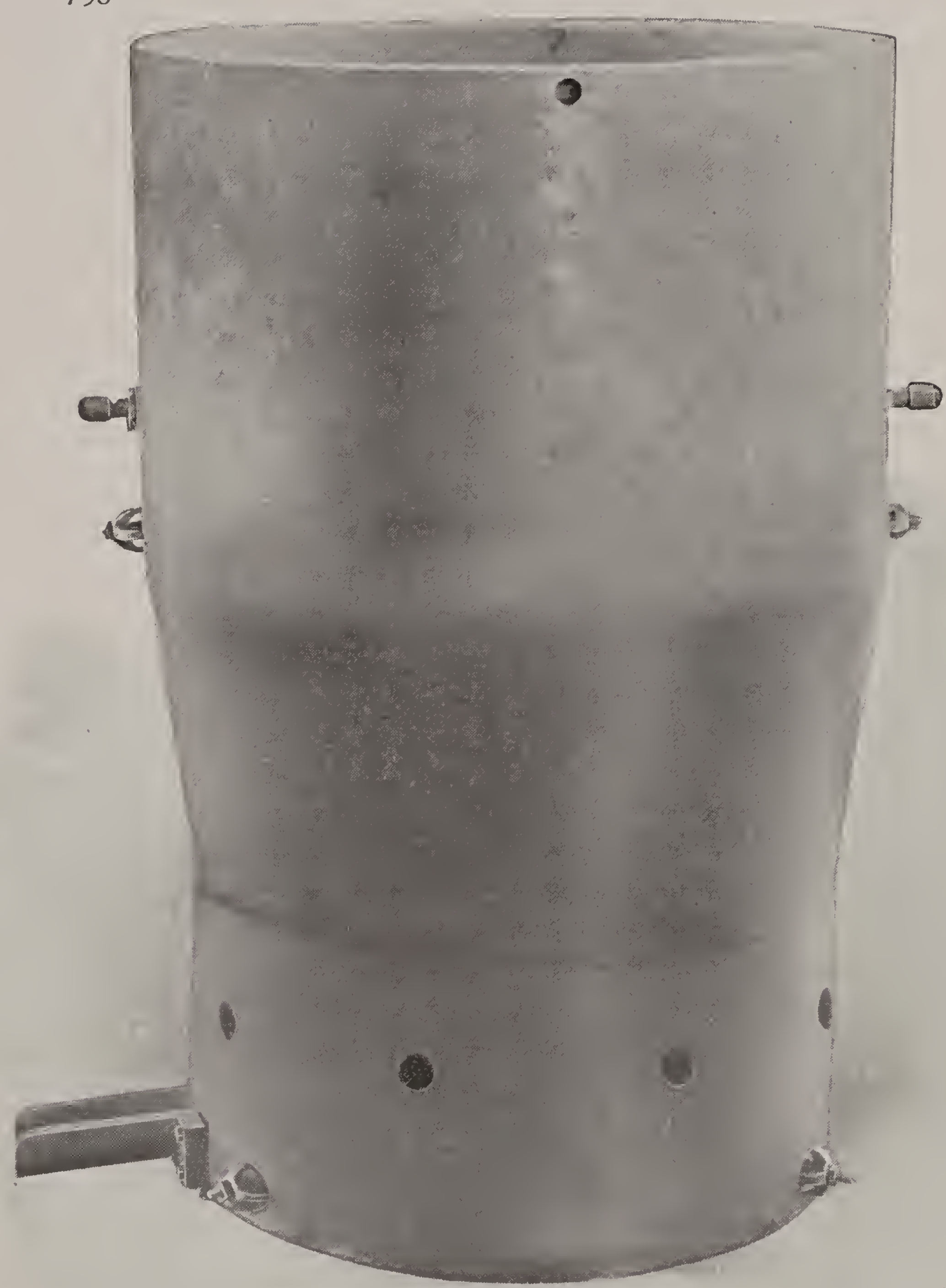


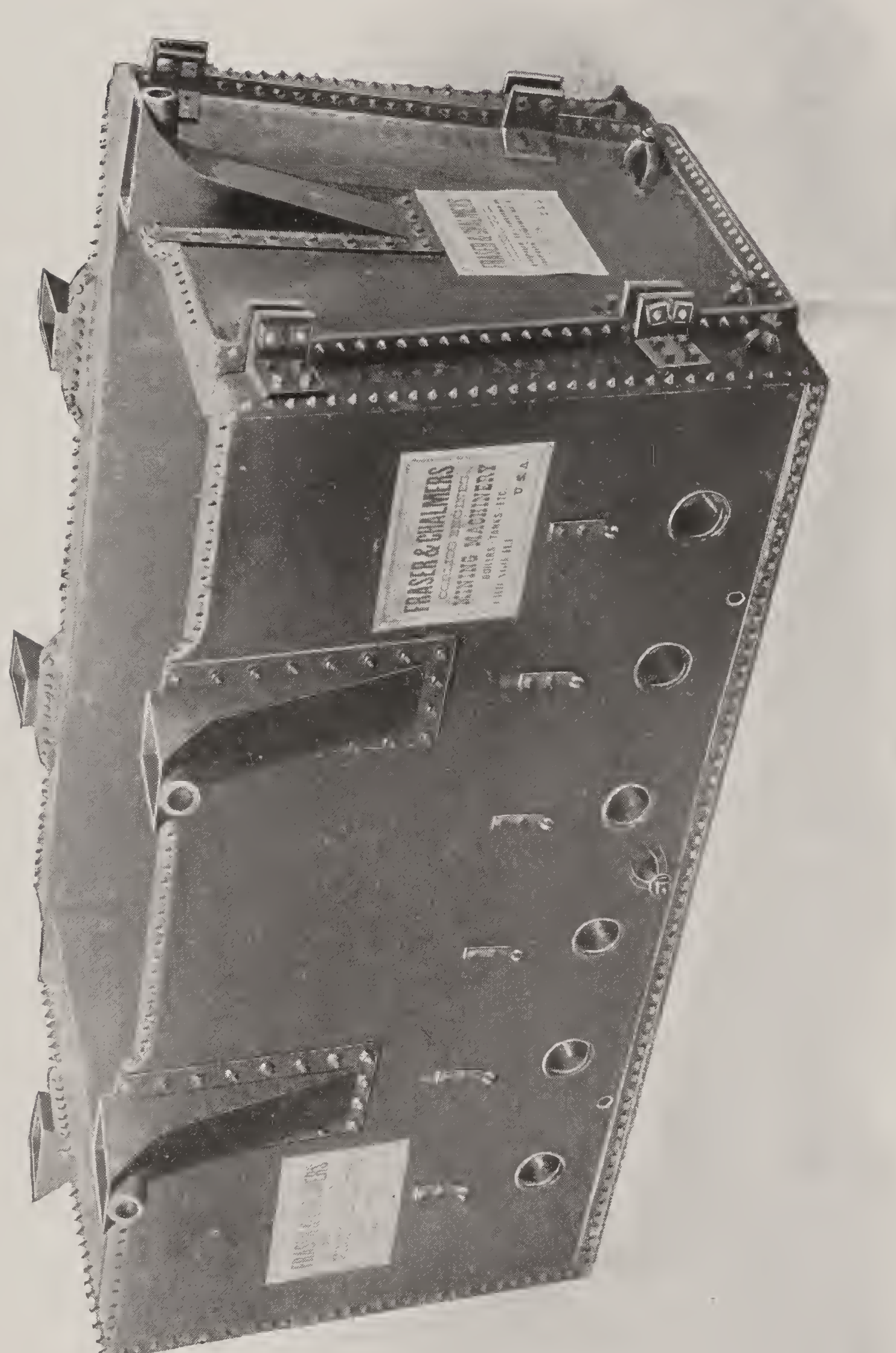
Plate 794

Set of Sectional Welded Steel Water Jackets for a Round Lead Blast Furnace

Plate 795

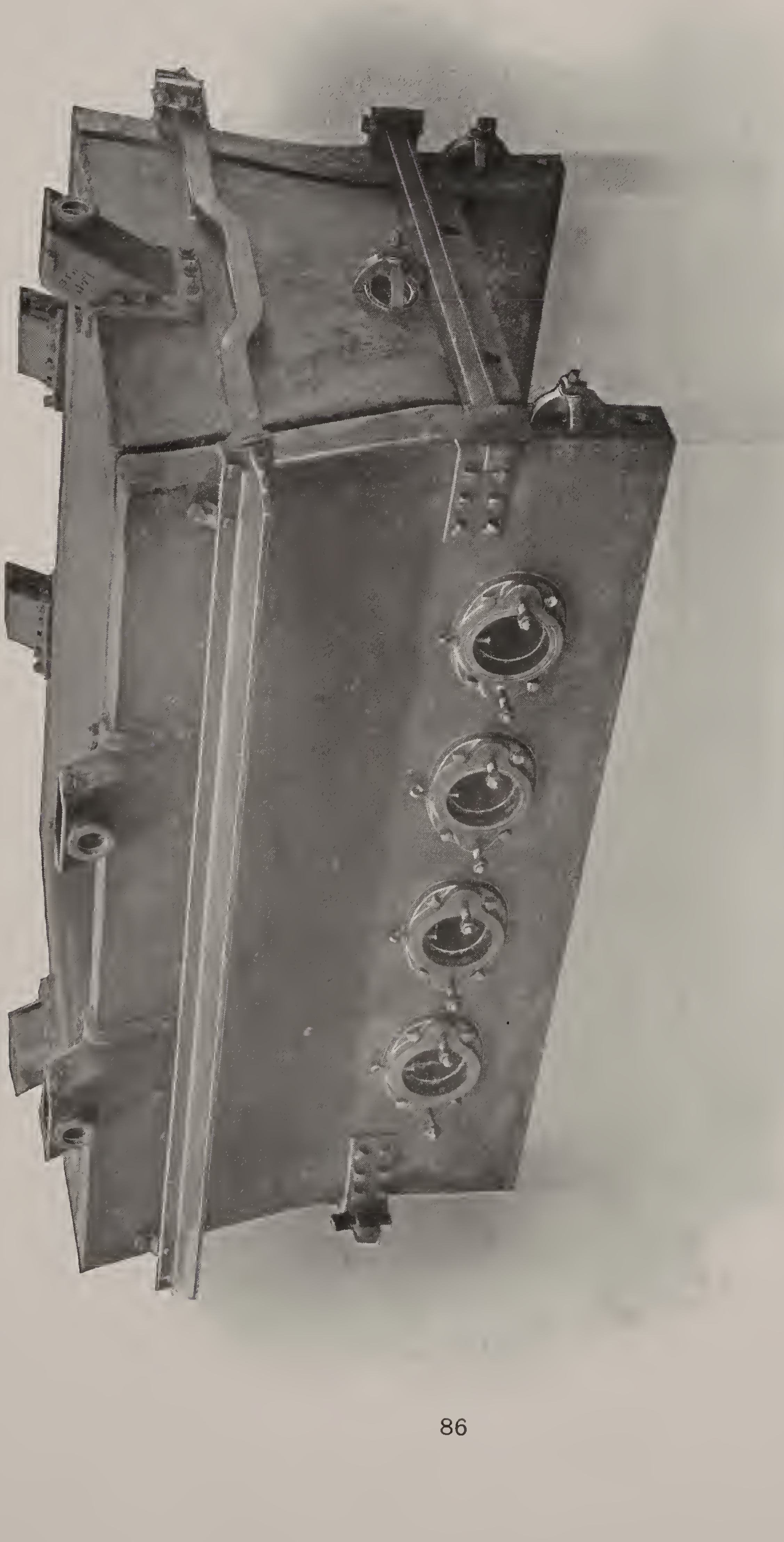


Seamless Sheet-Steel Water Jacket for a 48-inch Copper Furnace. Bretherton Design



Riveted Steel Water Jackets for a Lead Blast Furnace

Plate 792



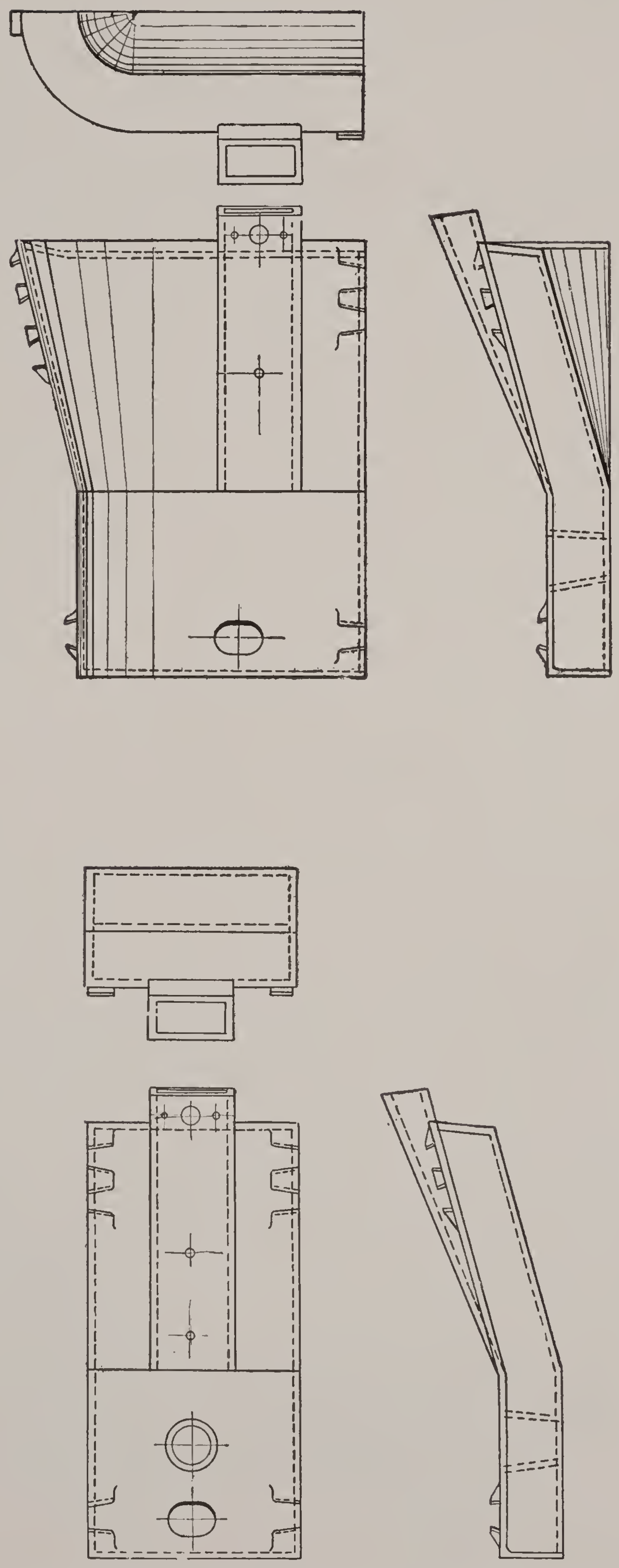
Welded Steel Water Jackets for a Lead Blast Furnace

Plate 793

Welded Steel Water Jackets, 8 feet high, for a Copper Blast Furnace

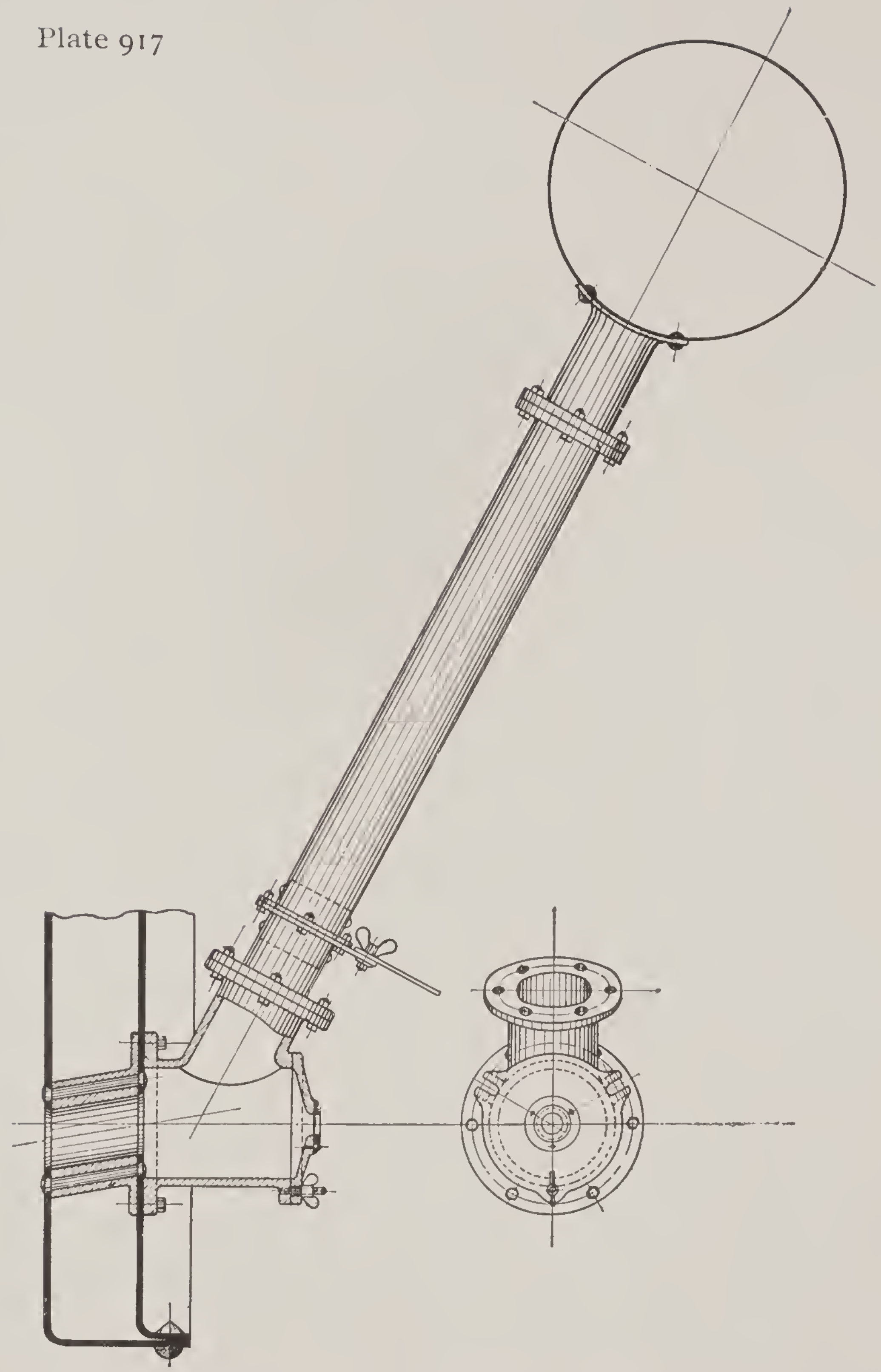
Plate 791

Plate 885



Cast-Iron Jackets for a Lead Furnace

Plate 917



INDIVIDUAL TUYERE=BOX

Plate 917 shows a design of individual tuyere-box which we furnish with large smelting furnaces. It is of cast iron, is bolted air tight to the water jacket and rigidly connected with the bustle pipe. It is provided with a large door having a mica-covered observation hole. In the lower part of the tuyere pipe there is a blast gate.

With this construction leakage of air is impossible, and the amount entering each tuyere can be nicely regulated.

FURNACE CAPACITY

The capacity of a furnace depends chiefly upon the amount of fluxes necessary, the fusibility of the charge and the pressure and volume of the blast. Any considerable quantity of fine material will lessen the capacity.

Although only roughly approximate, the following will suffice as a basis for computation of capacity under ordinary conditions. A furnace will smelt some 2½ tons of ore, or 3⅓ tons of ore and fluxes, per 24 hours for each square foot of area at the tuyeres. Large furnaces always work better than small ones and have a proportionately greater capacity. With carbonate ores a greater capacity will be attained.

When parties write to us for estimates on smelting furnaces and smelting plants, answers to the following questions will be of great service to us in preparing replies:

(1) The kind of ores to be smelted—copper or lead.

(2) Character of the ores. Send small pieces representing average character.

(3) Analyses and assays of the ore.

(4) Number of tons of ore to be smelted per 24 hours.

(5) If we are to quote price for a complete smelting plant, it will be necessary for us to know whether sampling machinery will be required, the percentage and kind of ores to be roasted; also final products.

(6) Should waterpower be available, head or fall in feet and cubic inches flow should be given.

(7) Should drawings be necessary, a rough sketch showing contour of the ground where smelter will be placed should be sent.

(8) Is the machinery to be of regular design, or to be made sectional for mule-back transportation?

Any other available data suggested by unusual conditions or requirements should be included, always bearing in mind that we shall be able to cover the requirements of the customer with a saving in time proportionate with the completeness of their answers to the foregoing questions.

The smallest furnace for copper or lead ores made by us has a diameter of 20 in. at the tuyeres and a capacity of some eight to twelve tons per twenty-four hours (a size smaller than this would be neither practicable to build nor at all satisfactory to operate). This size is used in metallurgical laboratories for making trial runs, also for smelting rich ores and jewelers' sweepings, but it is not well adapted for constant daily running at a mine.

Our next larger sizes are 24, 30, and 36 in. for either copper or lead, and 42 and 48 in. for copper ores. All of these are suitable for constant use.

With 48 in. the maximum diameter at the tuyeres has been reached; larger furnaces are of the rectangular type, of which we make all sizes from 33 x 60 in. to 44 x 168 in.

BLAST FURNACE ACCESSORIES

BLOWERS

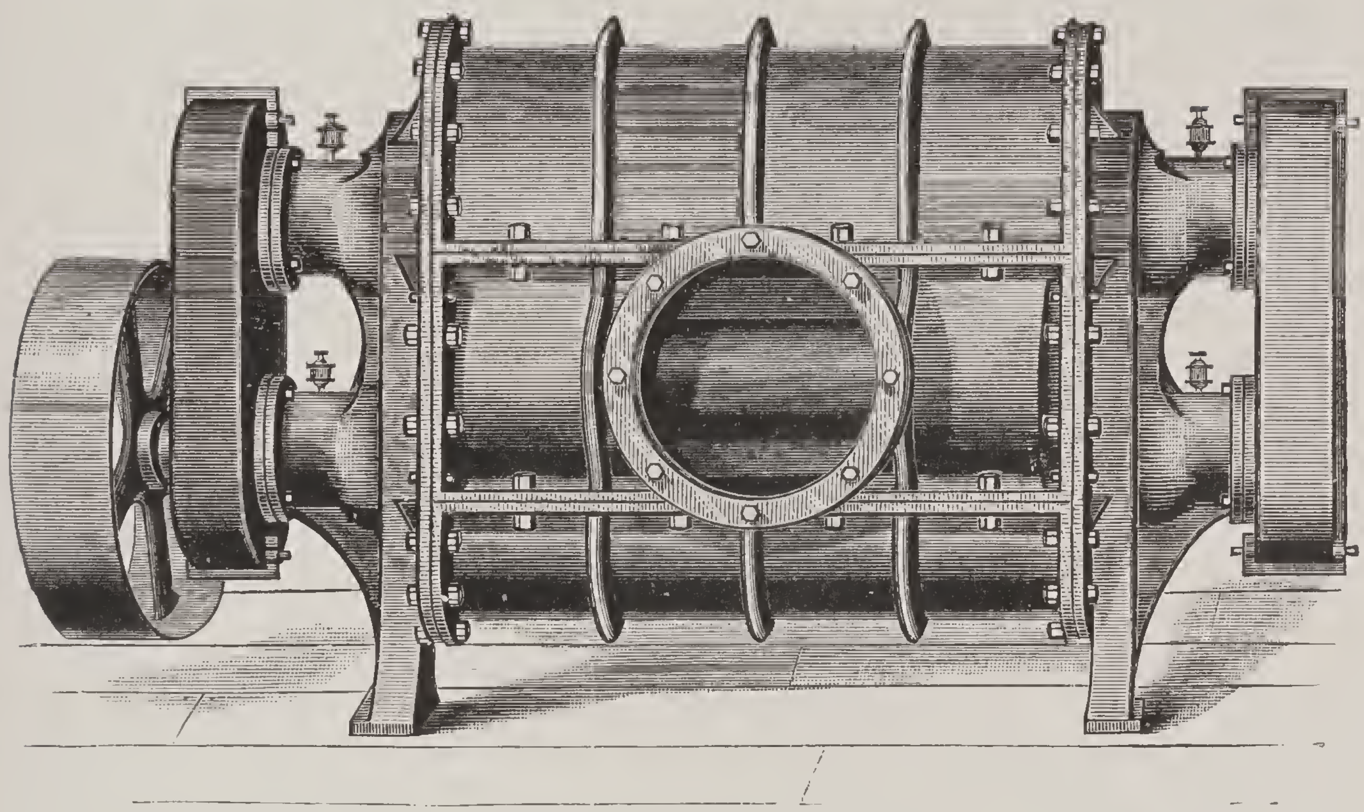
For supplying blast to smelting furnaces of small size, either a fan or a pressure blower can be used. The fan possesses the advantages of cheapness and in not requiring much power; when it is used it is best to have it mounted on an adjustable bed with a combined countershaft.

For large furnaces, pressure blowers are employed, usually the Green, Root or Connersville blower; all are two-impeller machines and constructed on more or less the same principles.

When the selection of a blower is left to us, we recommend the Green for use in connection with smelting furnaces, as we consider it the best blower in use.

We furnish the Root, or Connersville blower, when our customers are prejudiced in favor of these makes.

Plate 861



STANDARD GREEN BLOWER

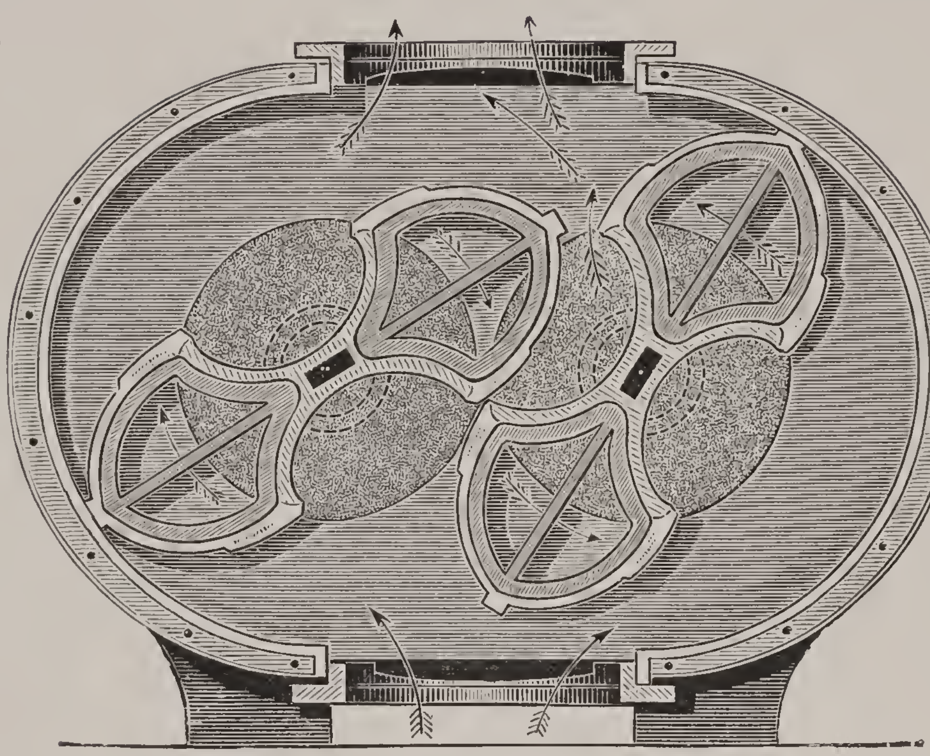
The above cut shows a Standard Green Blower with discharge outlet on either side. Blowers with discharge outlet at top or bottom are also kept in stock. Blowers with vertical engines or electric motors on same bed plate made to order.

The inlet and outlet flanges are tapped for tap or screw bolts and provided with loose flanges for attaching light sheet iron pipe.

A mercury pressure gauge is supplied with each blower.

NOTE.—Standard Blowers of a size smaller than No. 1, have one set of gear wheels and bearings cast on head plate.

Plate 863



Sectional View

THE GREEN BLOWER

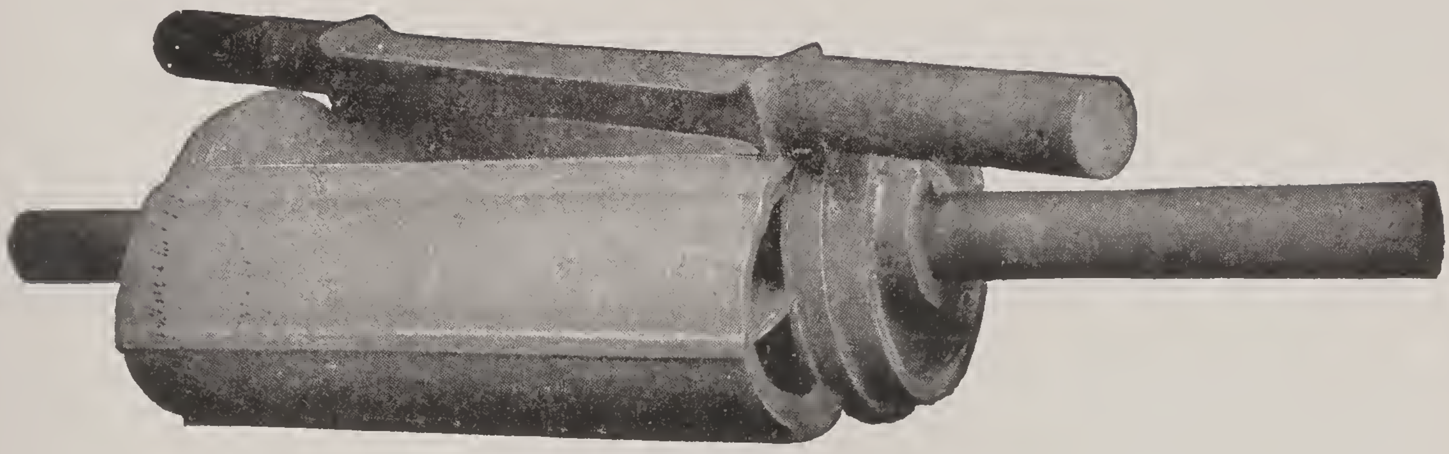
The working parts are two perfectly balanced impellers, each of which is a single strong casting, well ribbed inside and firmly fastened to a steel shaft of ample dimensions, extending the full length of blower. The journal bearings are bushed with phosphor bronze and are detachable from blower, being bolted and dowelled to the head plate, easily removed and returned to their original central position.

The blower is geared at both ends, the gearing being of ample proportions, cut in the most accurate manner, and enclosed in an oil-tight cover, free from dust and dirt, and continuously in oil. The casing of the blower is well proportioned, strongly ribbed and firmly bolted together.

The head plates, in addition to being well ribbed, are further strengthened by making the hoods or extensions, into which the circular ends of the impellers project, a part of head plate casting. The circular parts of casing and the pipe plates are also ribbed, and the pipe plates are fitted between and bolted to the head plates and circular casing.

In addition to the strength imparted to it by its being firmly ribbed, the casing is firm and rigid by reason of its proportionately short length, which is much less than that of any other two-impeller blower of the same displacement.

Plate 864



COMPLETE IMPELLER

The impeller is a single casting with a steel forged shaft. Two such pieces compose the interior working parts of blowers and exhausters.

The finished surfaces of the impellers are two circles, which roll together without friction, forming an even and continuous practical contact; the point of contact being always on the pitch line of the gears and traveling at the same speed at all points during the revolution.

In order to give additional strength to the impellers, and also as a protection in case the journals should become worn, the ends of the impellers are provided with circular heads or disks, which heads are part of the impeller casting. These heads or disks are truly turned, so that in case the journals should wear, the heads of the two impellers will roll together without friction and prevent the bodies of the impellers from coming into actual contact.

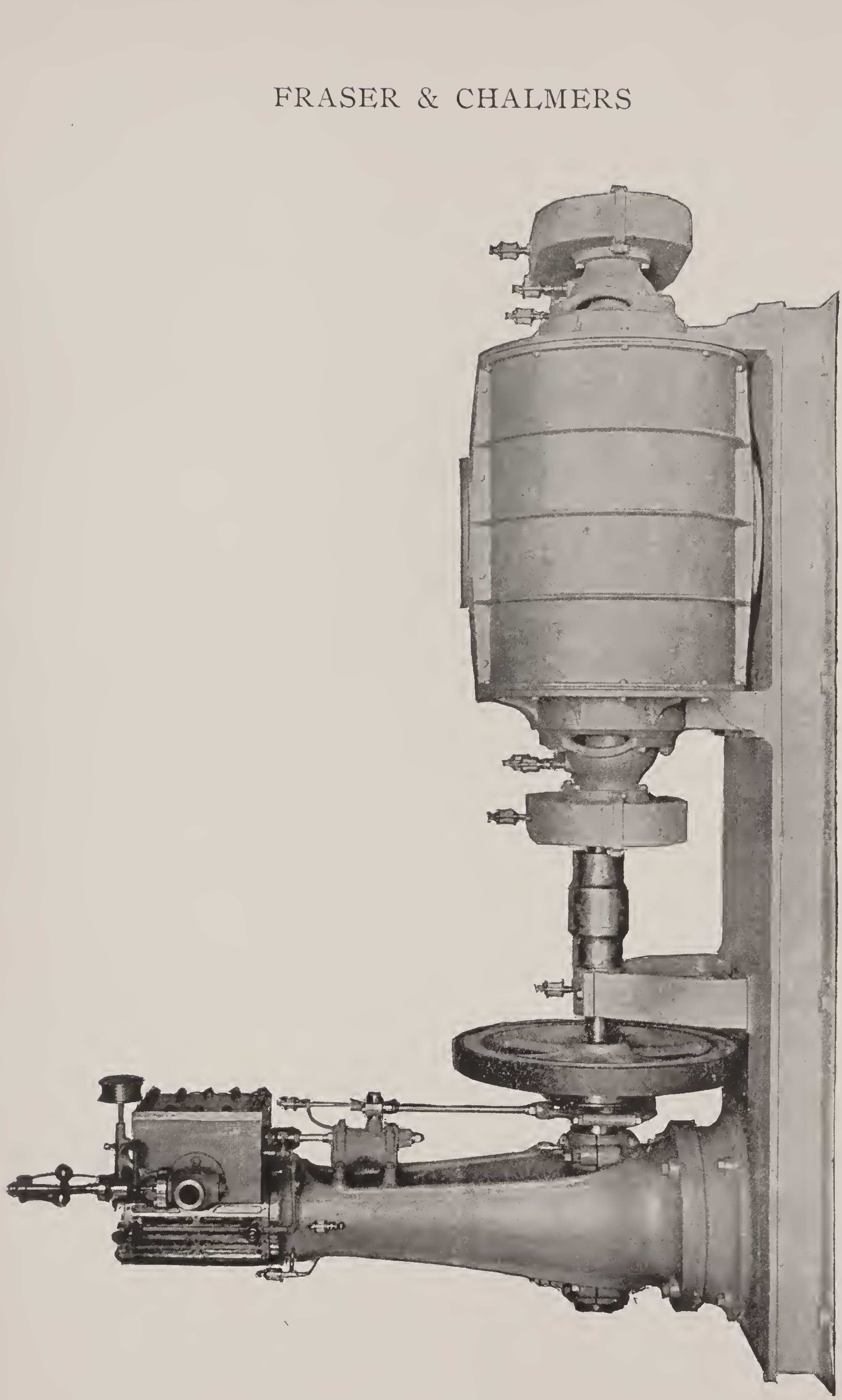
The gear wheels are keyed to the shafts close to ends of journal bearings, forming collars at each end of blower and preventing the impellers from rubbing endwise against the interior sides of head plates.

These provisions insure an entire absence of internal friction at all times, and are a positive preventive of accidents which might otherwise occur.

Note.— In all other two-impeller blowers, the peripheries of the impellers sweep or slide past each other, the contact surface of one impeller traveling faster than the contact surface of the other with an irregular, uneven contact. As there is no provision for preventing the impellers of such blowers from moving endwise, or from coming into actual contact, in case of wear to the journals the result is a large amount of internal friction and possible breakage of the impellers.

DIMENSIONS, WEIGHTS, CAPACITIES AND POWER REQUIRED FOR GREEN'S BLOWERS

Blower No.	1	2	3	4	4½	5	5½	6	7	8	9
Revs. for constant service	250	250	225	200	200	175	175	150	135	100	...
Displacement per Rev. in cu. ft.	3	5½	9	15	20	25	35	42	67	112	200
Diam. Discharge Opening	7 in.	10 in.	11¾ in.	14 in.	17 in.	17 in.	19 in	21 in.	24 in.	30 in	
Pulley	20x5 in	24x6 in.	30x6 in.	36x7 in.	40x8 in.	44x8 in	48x10 in.	48x12 in.	60x15 in.	.....	...
Weight of Blower	1500	2200	3100	4200	....	7000	9000	11000	19000	.....	...
Approx. H. P. for 1 lb. pressure	4	7	10	15	22	24	33	35	50	.....	...
Blower with Vertical Engine—											
Size of Engine	4x6 in.	5½x7in.	7x9 in.	8x9 in.	9x9 in.	9x12 in.	11x12 in.	12x12 in.	13x16 in.	.....	...
Weight of Blower and Engine	2800	4300	5500	8000	....	13000	17000	21000	33000	.....	...



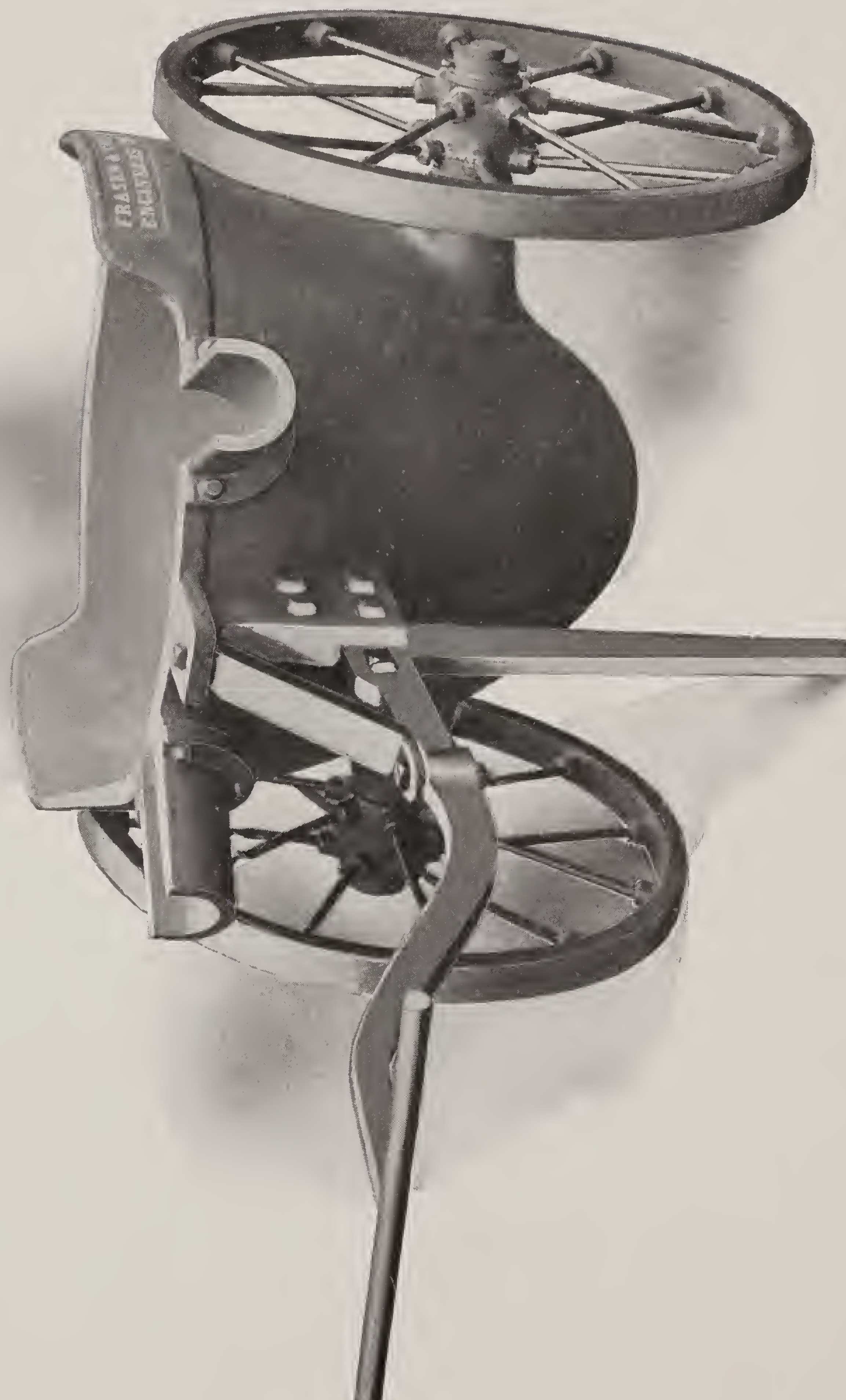
Standard Green Blower
With Vertical Engine attached to the same Bed-Plate

Plate 862

STANDARD GREEN BLOWER

With Vertical Engine Attached to the Same Bed-Plate

Plate 862 shows a blower directly connected with a vertical engine, both being bolted to the same bed-plate, which is often a desirable arrangement when only one or two blowers are used. When, however, a number of blowers are to be used, the best and most economical arrangement is to drive them together by one high duty engine, a duplicate engine being kept in reserve.



Settling Pot

Plate 845

Forehearth

Plate 801

No. 8 Slag Pot with Anti-Friction Roller Bearings

Plate 790

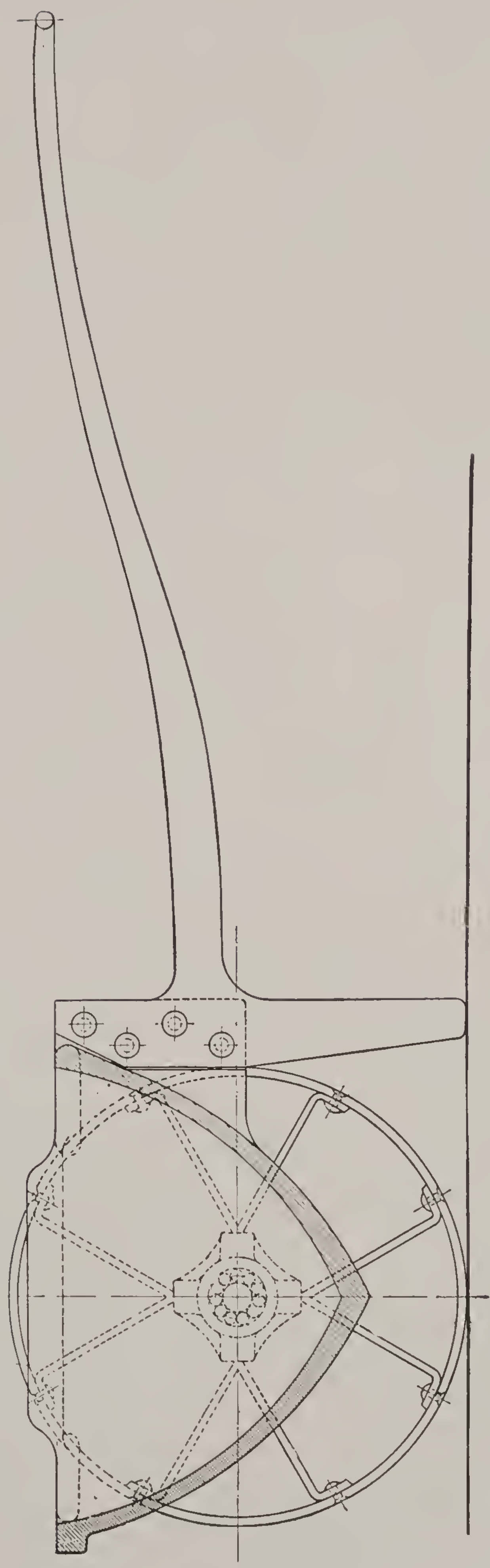


Plate 856

No. 9 Slag Pot with Anti-Friction Roller Bearings

FOREHEARTHS

By the use of the forehearth a separation of matte or metal from slag is obtained outside of the furnace; it is in fact an exterior crucible.

For small furnaces, a large Settling Pot (Plate 845) can be conveniently used for this purpose. The pot is provided with two spouts so that when one slag pot is filling another can be placed in position; they are of such height that the bowl of the ordinary slag pot will pass beneath them; the wheels are provided with roller bearings.

For large furnaces, correspondingly large forehearths are used; they are usually rectangular boxes of cast iron lined with fire-brick and mounted on four wheels (see Plate 801).

They are also made with steel-jacketed sides and cast-iron bottoms.

In large copper-smelting plants where matte is bessemerized, stationary forehearths holding as much as 10 tons are sometimes used; from these the matte is tapped either directly into the converter or into a ladle handled by an electric crane.

Recently a large tilting forehearth has been introduced, which is somewhat similar to the tilting steel furnace, the tilting being performed by hydraulic mechanism.

SLAG POTS

Plate 790 shows our Standard No. 8 Slag Pot, which is used by many smelting companies. The wheels are fitted with anti-friction roller bearings, and it is made throughout to withstand rough usage. The complete slag pot weighs 500 lbs., the bowl separately 290 lbs; capacity, 2 cubic feet.

Another desirable form of slag pot is shown in Plate 856. The construction is somewhat lighter; the wrought-iron leg and handle are made in one piece, riveted with hot rivets to the lug cast on the bowl; the spokes are of flat steel, the hub being cast around the inner ends while the outer ends are bent at right angles and riveted to the steel rim. This is an excellent pot and capable of long service.

We make slag pots of several other designs for special service, such as litharge pots, the bowls of which are flat on the bottom and detachable from the carriage.

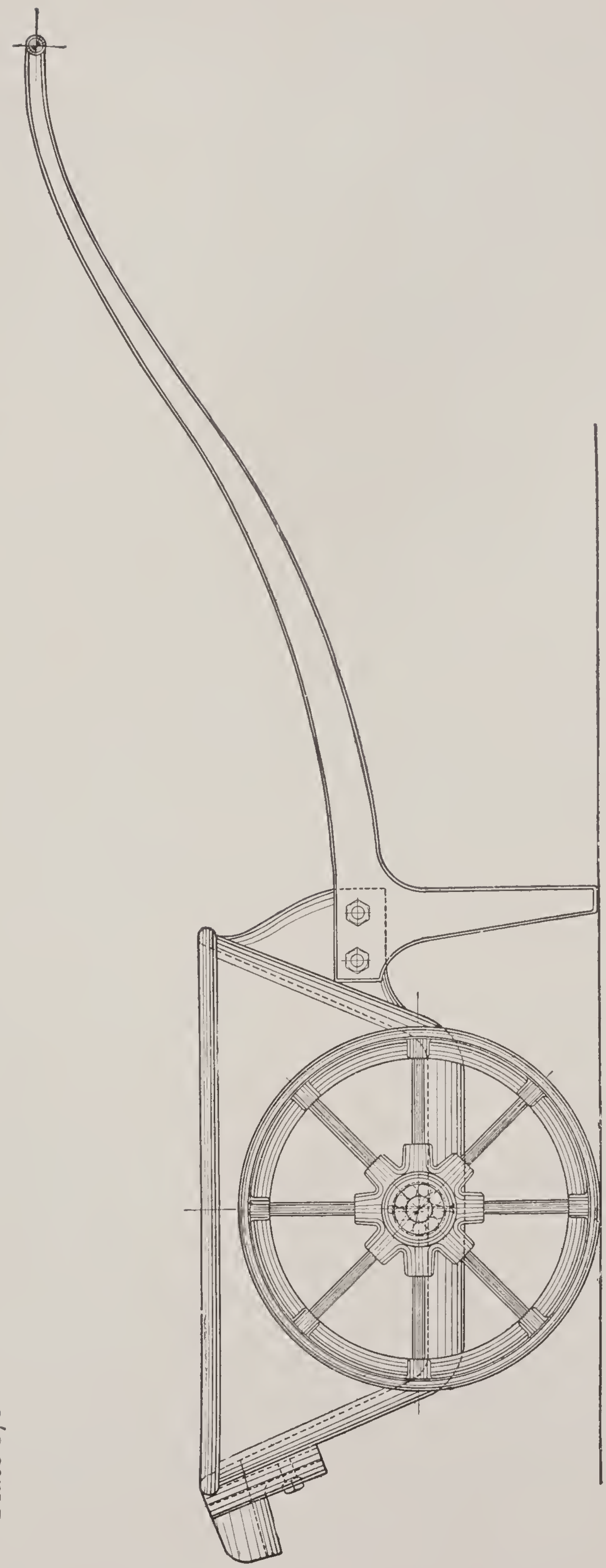
We also make slag pot bowls of a special foundry mixture, which we call "semi-steel", which is much less liable to crack than cast iron; its use permits of lighter construction.

A cast-iron button (see Plate 926), is sometimes inserted in the bowl to receive the splash from the molten slag.

COPPER BULLION POT

Plate 876 shows our Copper Bullion Pot mounted on wheels provided with roller bearings. Weight of the mold and carriage complete 700 lbs.; weight of the mold 525 lbs.

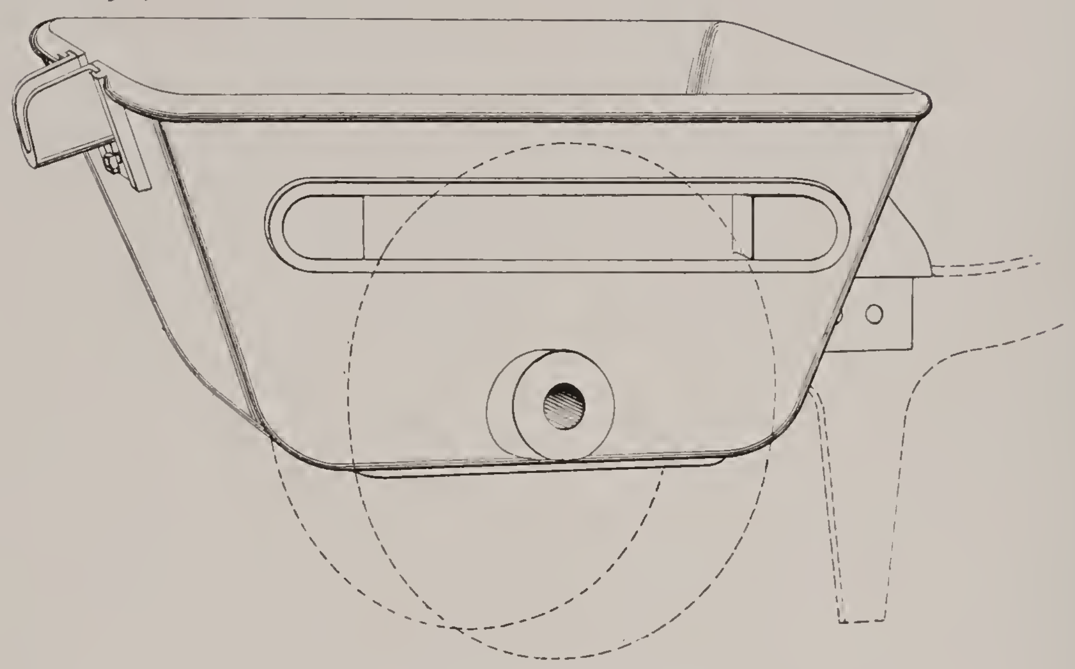
This pot is also made with lugs projecting from the bottom and sides of bowl around which wrought-iron bands are shrunk (see Plate 927), thus preserving its usefulness should cracks appear in the bowl after long usage.



Copper Bullion Pot

Plate 876

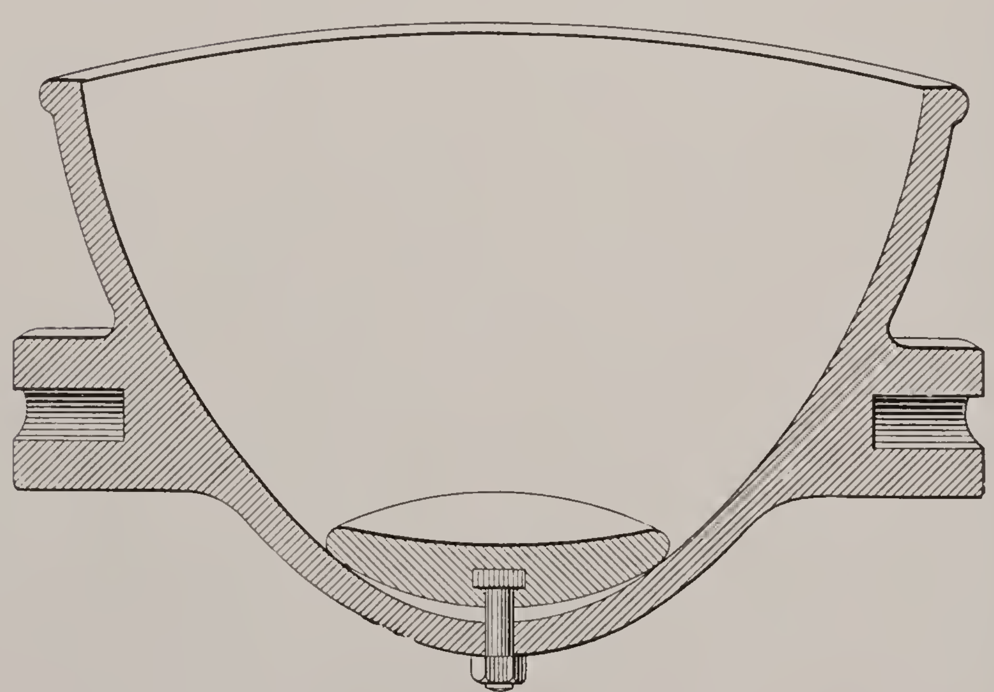
Plate 927.



Copper Bullion Pot

Showing method of re-inforcing the bowl.

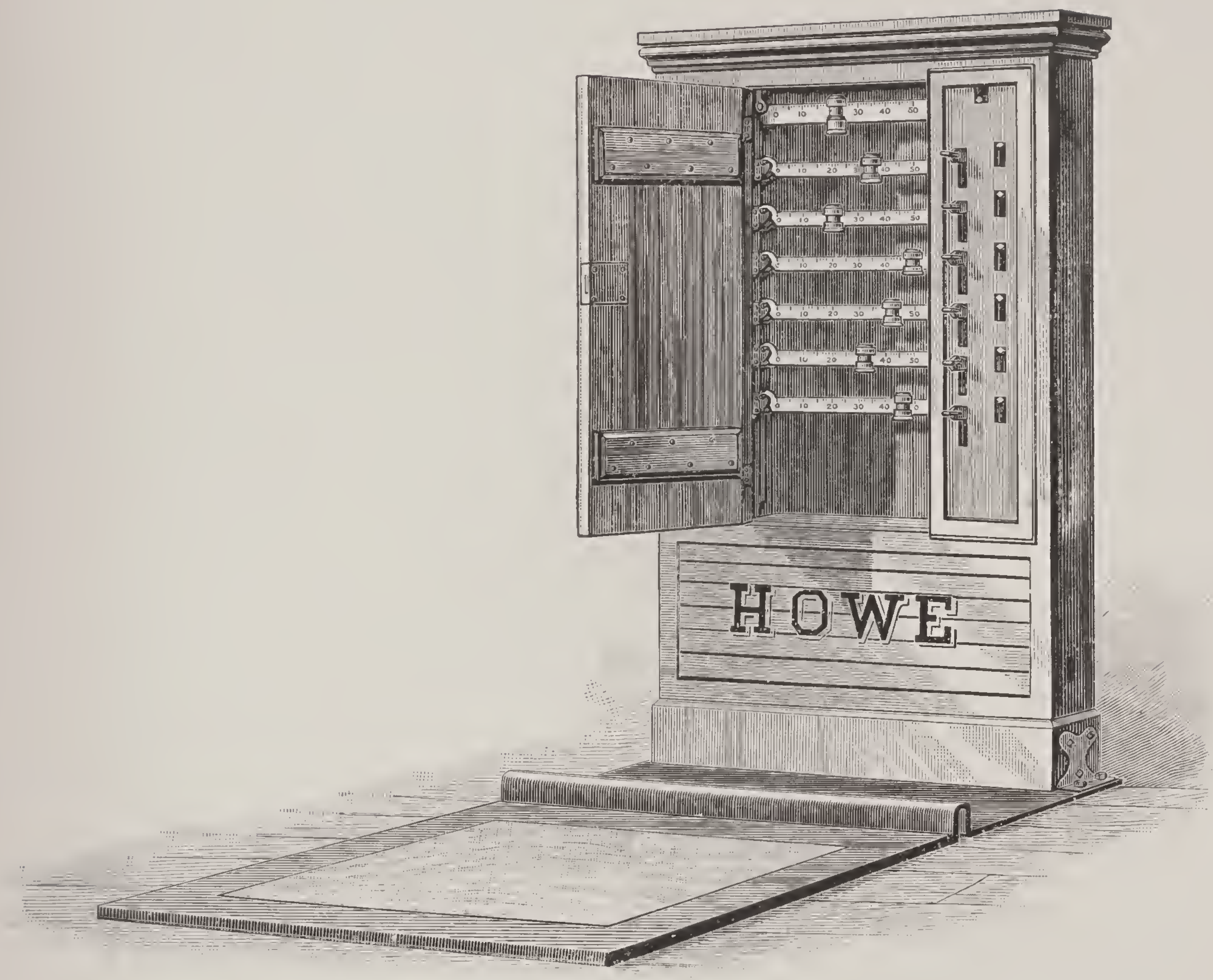
Plate 926.



Slag Pot

Section of bowl showing the application of splash button.

Plate 836



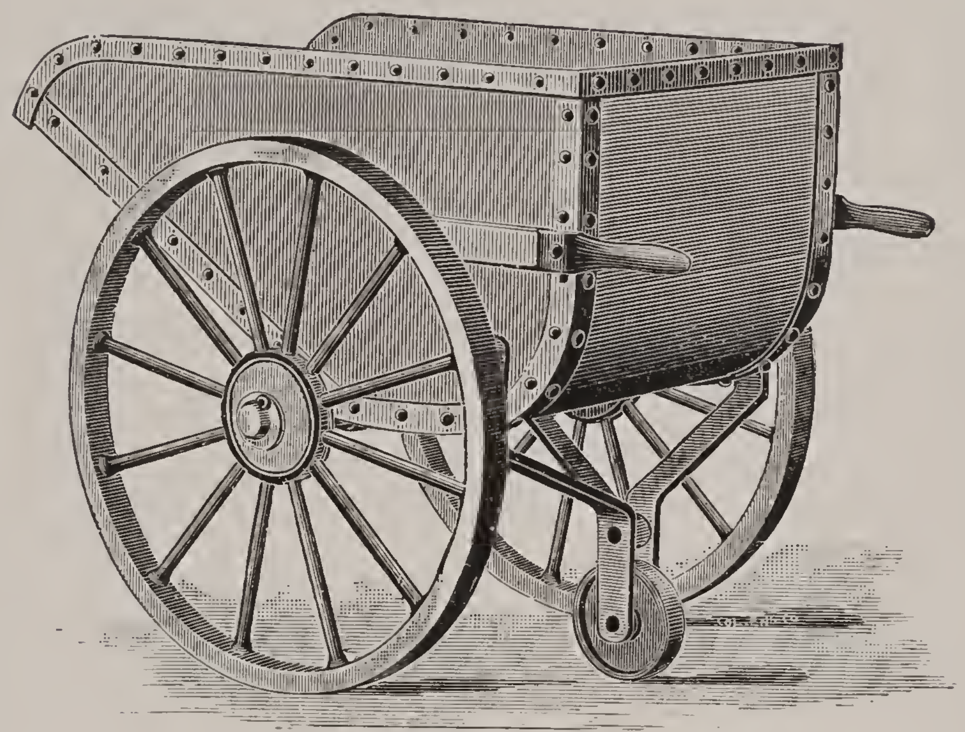
SCALES FOR WEIGHING FURNACE CHARGES

These scales are made in the most substantial manner. They have four or more brass beams, each separate from the others; 1,500 pounds can be weighed on each beam by 5 pounds.

After being adjusted the beam box can be closed and locked, thus placing it entirely beyond the control of the workmen.

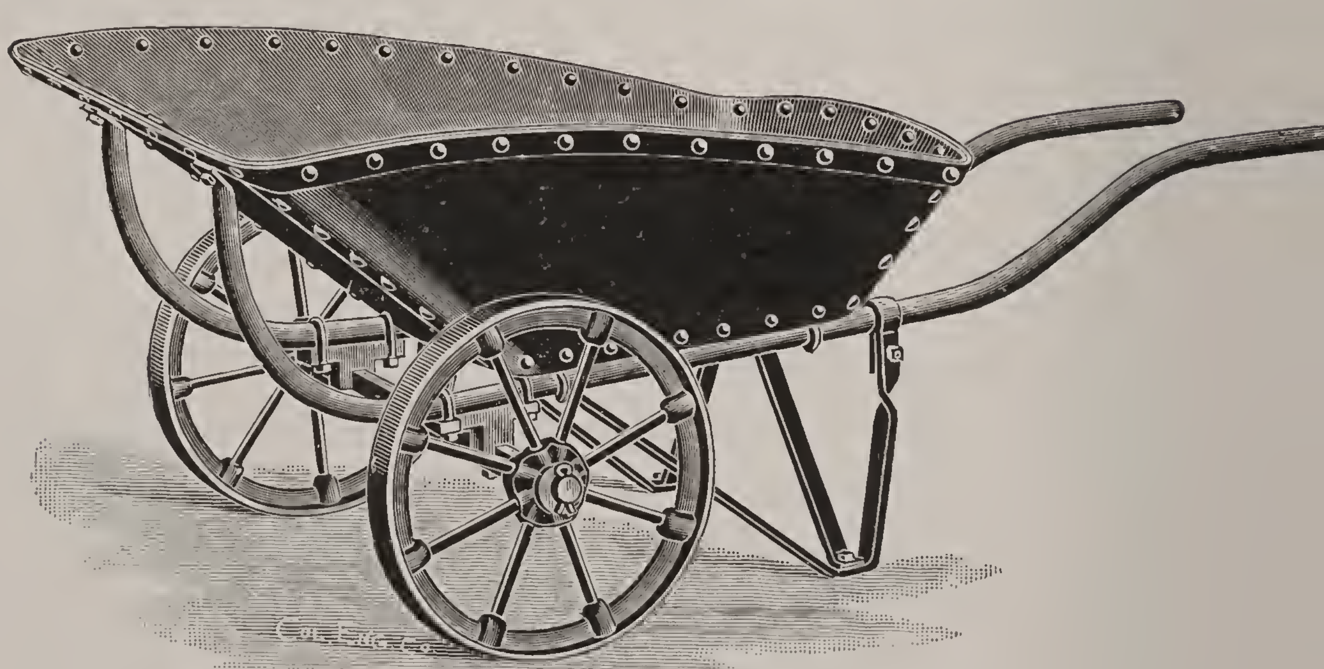
We also furnish all other scales used in the treatment of ores, viz.: Moisture Scales, Wheelbarrow Scales, Dormant Warehouse Scales, Railroad Track Scales, etc.

Plate 901



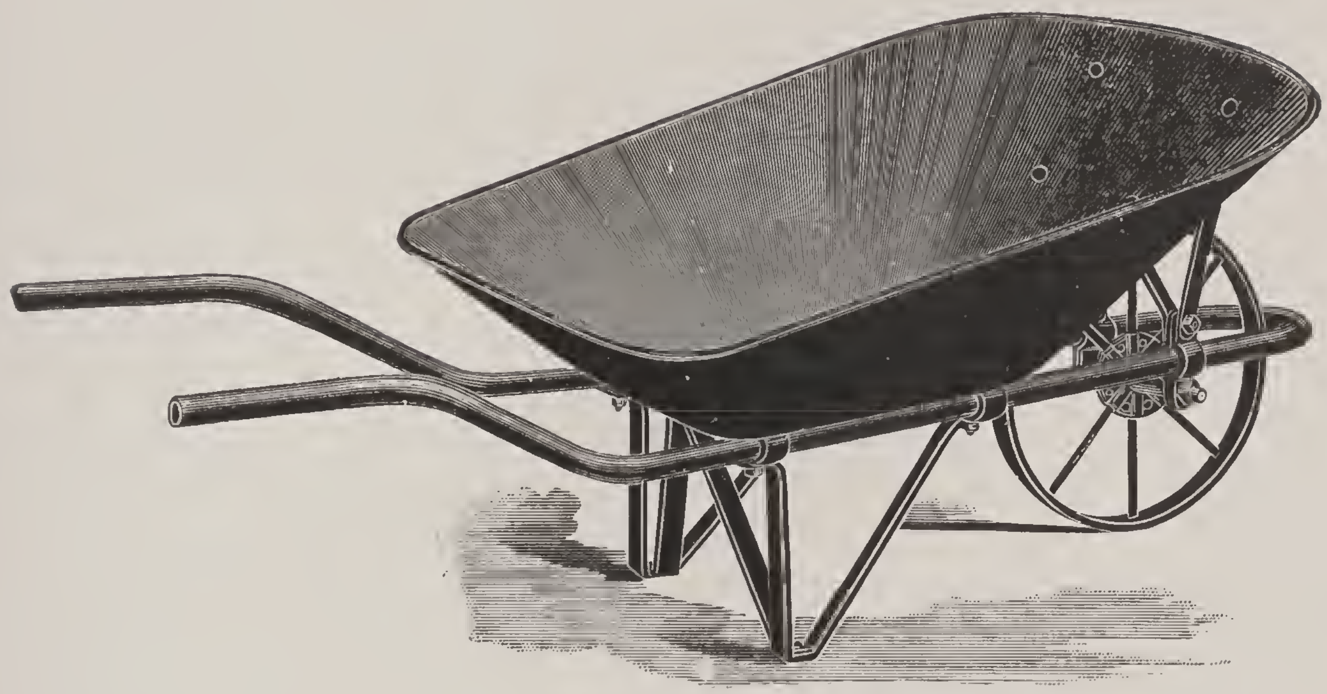
Steel Charging Barrow

Plate 902



Two=Wheel Coke Barrow

Plate 903



TUBULAR STEEL TRAY BARROW

With smelting equipment we furnish Charging Barrows, Coke Barrows and Tray Barrows, all made of steel and of the best construction to stand hard usage.

The Charging Barrow with plain or with anti-friction roller bearings weighs 575 pounds and has a capacity of 10 cubic feet.

The Two-Wheel Coke Barrow weighs 220 pounds and has a capacity of 10 cubic feet.

The Tray Barrow usually furnished weighs 109 pounds and has a capacity of 6 cubic feet.

We also furnish smaller barrows.

LEAD MOLDS

These are made of cast iron, steel or semi-steel, weigh 45 pounds, and have a capacity of 100 pounds of lead bullion. A clean, smooth casting is guaranteed and they are cast with the name of the company in raised letters in the bottom.

FINE BULLION MOLDS FOR GOLD AND SILVER

These are made of the best iron or steel, absolutely free from flaws. Each mold is dressed out and ground smooth inside with perfect taper on sides and ends.

WATER TANKS

We furnish Water Tanks of wood or steel and of any size and style required; large sizes cannot be loaded on cars and are shipped knocked down.

ELEVATORS FOR SMELTING WORKS

In smelting works of any considerable size there is much material, such as slag shells, roasted ore, furnace breakings, etc., which require to be smelted, and to raise such material from the dump to the charging floor an Inclined Slag Hoist or a Platform Elevator is employed. We furnish these elevators of a size and construction to suit the requirements.

LARGE SMELTING PLANTS

The design and arrangement of a smelting plant depend upon the nature and magnitude of the work to be done. In the selection of a site, such points as the convenient relation of the parts, avoidance of hand labor as much as possible, disposition of slag, etc., are of paramount importance and should receive due attention. Considered from all points, a somewhat terraced site is most advantageous.

A large smelting plant may consist of several departments, viz.: sampling works, sulphide mill, roasters, blast furnaces, steam power, and electric light plants. Connected with a lead plant there may be a refinery, and with a copper plant, bessemerizing and electrolytic departments, all planned according to the magnitude of the works, the character of the ores and the products which it is desired to produce.

Unless a lead smelter is central to the lead market, it seldom has a refinery, and in remote localities copper refining is not carried on.

It is almost essential that a large plant be situated on or near a railroad.

In order to give a comprehensive idea of the general arrangement and construction of a modern silver-lead smelting plant, we introduce Plate 906, which shows plan and elevation of a 500-ton plant.

At the sampling plant all ores which require crushing are received. Ores which have to be held are stored in the storage bins. Sulphide ores which have to be roasted are crushed in the sulphide plant. Ores which go direct to the blast furnaces are unloaded at the ore-beds, a small portion going to the sampling plant.

In the space marked "yard" and in the space below it, ores, fluxes and fuel are stored; that portion of the yard next to the roasting furnaces is used as a cooling-floor for roasted ore.

While only a few roasting furnaces are indicated, others can be placed on the opposite side of the flue and connected with the same.

Standard and narrow gauge railroad tracks bring all points of the plant within easy access.

The blast furnaces, five in number and of large size, are placed in a row and connect with a dust chamber built back of a retaining wall; this dust chamber connects with the same stack as the roasters.

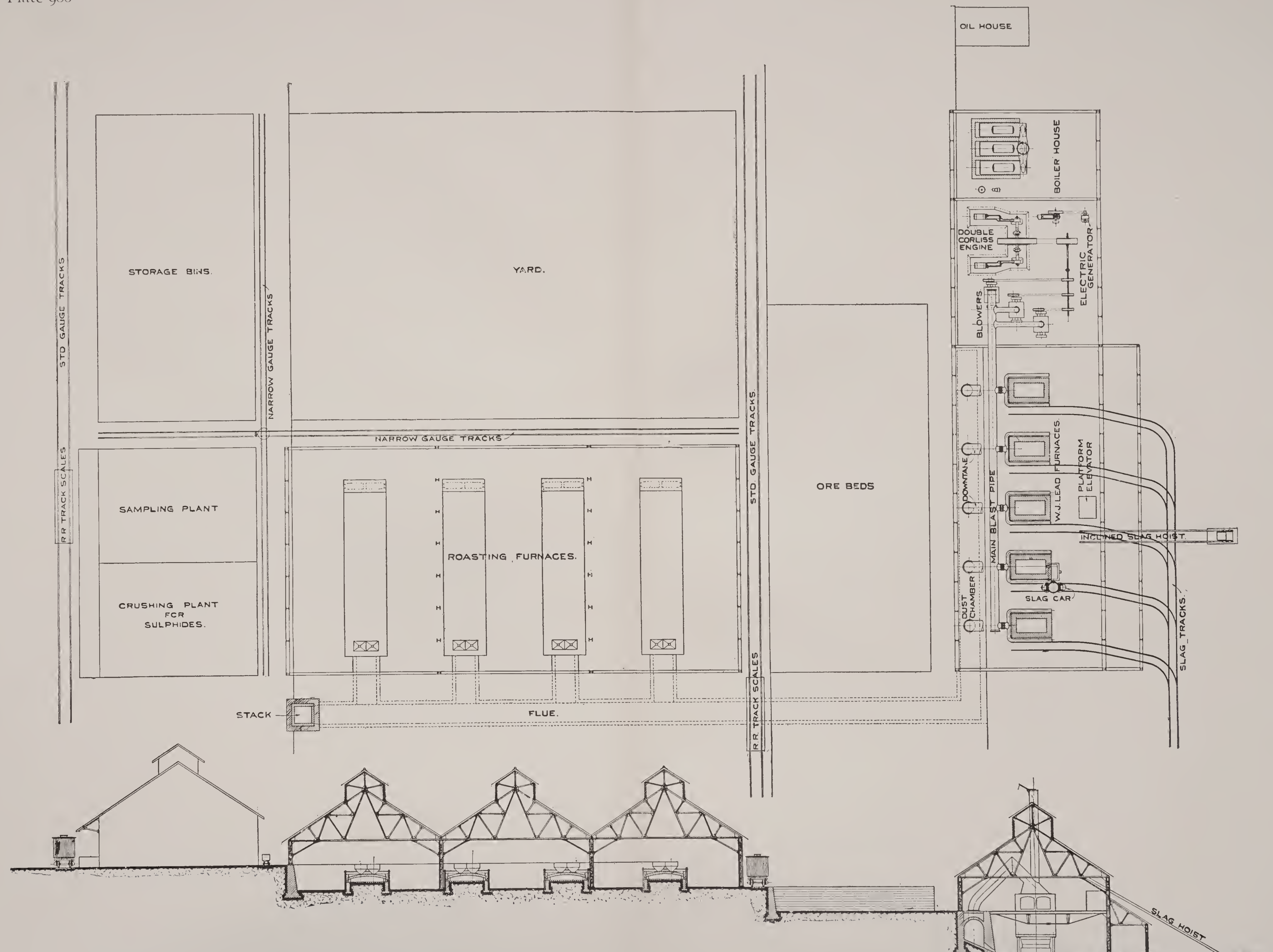
The position of the blowers is shown; all deliver air into a large main located between the furnaces and the retaining wall; they are run by a single Corliss engine, a duplicate engine being kept as reserve.

There is a small engine for running the electric generator which supplies electricity for lighting and for motors which run the platform elevator, slag hoist and an electric locomotive which draws the slag cars. One of these slag cars, as shown, is receiving its load of molten slag from a forehearth.

In the boiler house there is reserve boiler capacity.

Small buildings, such as the superintendent's office and laboratory (which are usually built together), store-house, blacksmith shop, etc., are not shown.

The more important buildings are of steel construction.



Modern Silver-Lead Smelting Plant

SMALL SMELTING PLANTS

We introduce Plate 849 to show the general arrangement of a small copper-smelting plant; a small lead-smelting plant differs from it in very little except in the kind of furnace employed.

Such a plant is best located where a natural difference in level of about 12 feet can be secured (this height being the distance between the furnace-room and the charging-floor), and where there will be a fall-off or slope to the ground in front of the furnace, so as to permit of easy disposition of slag.

The building, with the exception of the charging-floor and the timbers which form its outer support, may be of light construction and is best covered with corrugated iron. The engine and blower should be in a room partitioned off from the furnace and under a lower roof, while the boiler may be under a shed.

Very little brick-work is required; the blower and engine may rest on stone foundations, and, if necessary, a boiler of the locomotive type which requires no brick setting, can be used. The four short columns which support the furnace should rest on a stone foundation.

The drawings we furnish with such a plant contain all details necessary to enable an ordinary machinist and a local carpenter to erect the machinery and put up the building.

The following copy of our standard specifications for a 30-ton copper-smelting plant gives a description of our standard 36-inch, round, steel water-jacketed blast furnace for copper ores and all accessories required for a complete plant.

SPECIFICATIONS FOR A 30-TON COPPER-SMELTING PLANT

Furnace

1 Steel Water-Jacketed Copper-Smelting Furnace, same as shown in Plates 80 and 859, and consisting of:

1 Water Jacket 36 inches inside diameter at the tuyere level by 9 ft. high, made of the best flange steel. The jacket to be made in one piece, the seams being either riveted or welded together. Jacket to have six tuyeres, removable wind-box, hand-holes, inlet and outlet water connections.

1 Cast-iron bottom plate, with two semi-circular dumping or drop doors.

1 Jack Screw for holding these doors in place.

4 Cast-iron columns for supporting the furnace.

1 Sheet-steel hood and stack to pass through roof of building.

Blower

1 Rotary Positive Pressure Blower, having iron impellers and top discharge; speed, 200 revolutions per minute; displacement per revolution, 15 cubic feet.

Blast Piping

All necessary galvanized iron blast piping, three elbows, flanges, gaskets, bolts, relief valve and air-gate for connecting the blower with the furnace.

Furnace Accessories

1 Howe 4-beam charging scales, platform 43 inches square.
2 Large settling pots, mounted on carriages, same as Plate 845; it being intended that these pots be used as fore-hearths.
6 Improved No. 8 slag pots, with carriages. Plate 790.
3 Bullion Pots, with carriages, Plate 876.
All the above pots to have anti-friction roller bearings.
1 Steel Charging Barrow.
1 Two-wheel Steel Coke Barrow.
6 Tubular Steel Wheelbarrows.
1 Coke Fork.
1 Scoop Shovel.
6 Long-handled Steel Shovels.
2 Sledges with handles.
300 lbs. steel furnace bars, assorted lengths and sizes.

Engine

1 8x10 inch horizontal self-contained slide-valve engine, to be complete in every particular, including two pulleys, governor, governor belt, throttle valve, sight-feed lubricator, oil cups, cylinder and air bibbs and foundation bolts.
1 piece 4-ply rubber belting, 7 inches in width, to connect engine with blower.

Boiler

1 15-H. P. portable locomotive boiler, "water bottom" type, mounted on skids, complete with grates, steam and water gauges, gauge cocks, whistle and pipe, safety, blow-off, check and stop valves, smokestack and guy ropes. This boiler is to be constructed for a working pressure of 100 lbs. to the square inch.

Pumps, Heater and Piping

1 Duplex boiler feed pump, 2½ x 1½ x 2 inches.
1 Boiler feed injector.
1 Duplex steam pump, 3 x 2 x 3 in., for supplying water to tank.
All necessary steam and water piping, fittings and valves for making connections between boiler, engine, two pumps, injector, heater, tank and furnace.

Tank

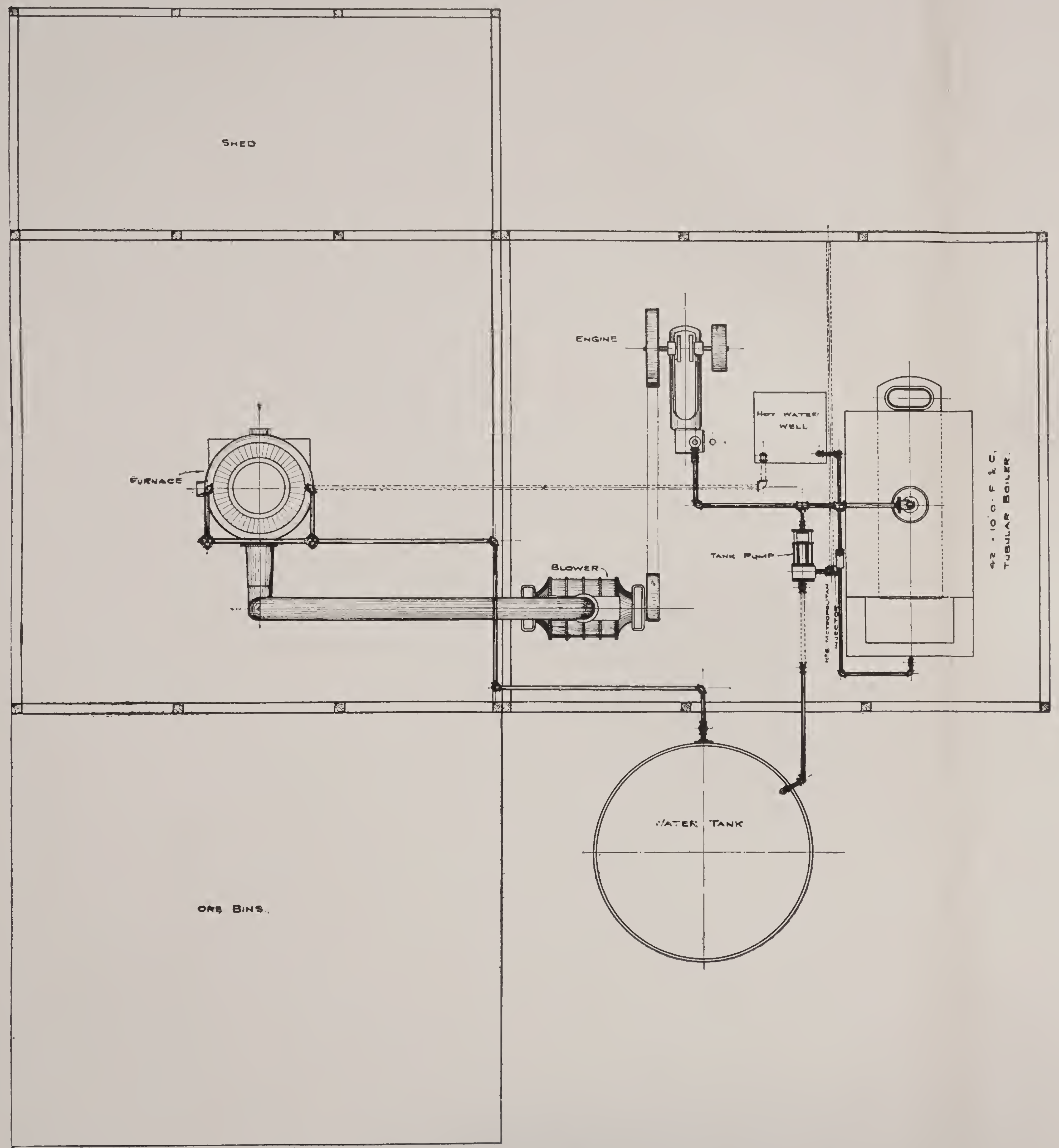
1 Round wooden water tank, 10 x 10 ft., to hold 5,100 gallons; to be made of 2-inch dressed lumber and bound with eight hoops.

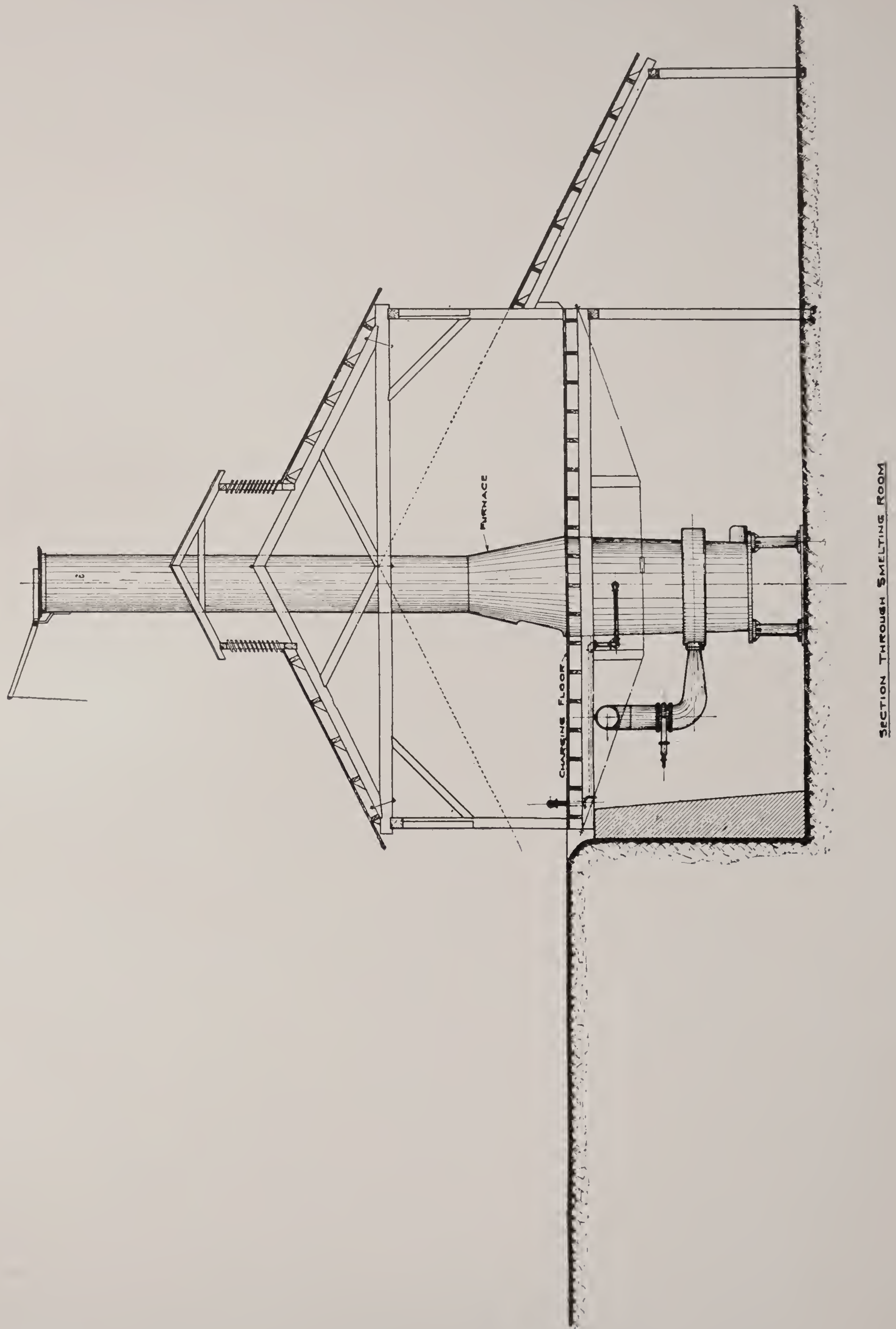
Building Bolts

All building bolts required in the construction of a building to contain this machinery and to be designed by us.

Drawings

All drawings necessary for the erection of this machinery.





Small Copper-Smelting Plant

GENERAL SMELTING OPERATIONS

Several years ago, when we published the first edition of this catalogue, the metallurgy of copper and lead in the United States was in its infancy, and the only literature on the subject available to English reading people was Dr. Percy's work, "The Metallurgy of Lead", and Mr. Vivian's little book on "Copper Smelting" as practiced in Swansea.

On account of this lack of information on the subject of general smelting operations when we all were students in the business, we thought it would be of some little value to our customers to devote a few pages to "Advice on the Running of Smelting Plants".

Since that time, however, books have been published which treat the subject exhaustively and much better than we could do within the limited space at our disposal.

We refer our customers who require such information to two most valuable metallurgical treatises:

"The Metallurgy of Lead," by Prof. H. O. Hofman;

"Modern Copper Smelting," by E. D. Peters Jr.

In these books the smelting of lead and copper ores, furnace work, etc., are thoroughly described, and our customers will find in them all the knowledge on the subject obtainable from books.

COST OF SMELTING

In order to estimate the cost of smelting it is necessary to be acquainted with the character of the ores, know the percentage of fluxes to be added to make a proper smelting mixture, also the cost of these fluxes, and of fuel, price of common and skilled labor, size of the plant, etc. If the ores require roasting, the cost for treatment will be considerably augmented.

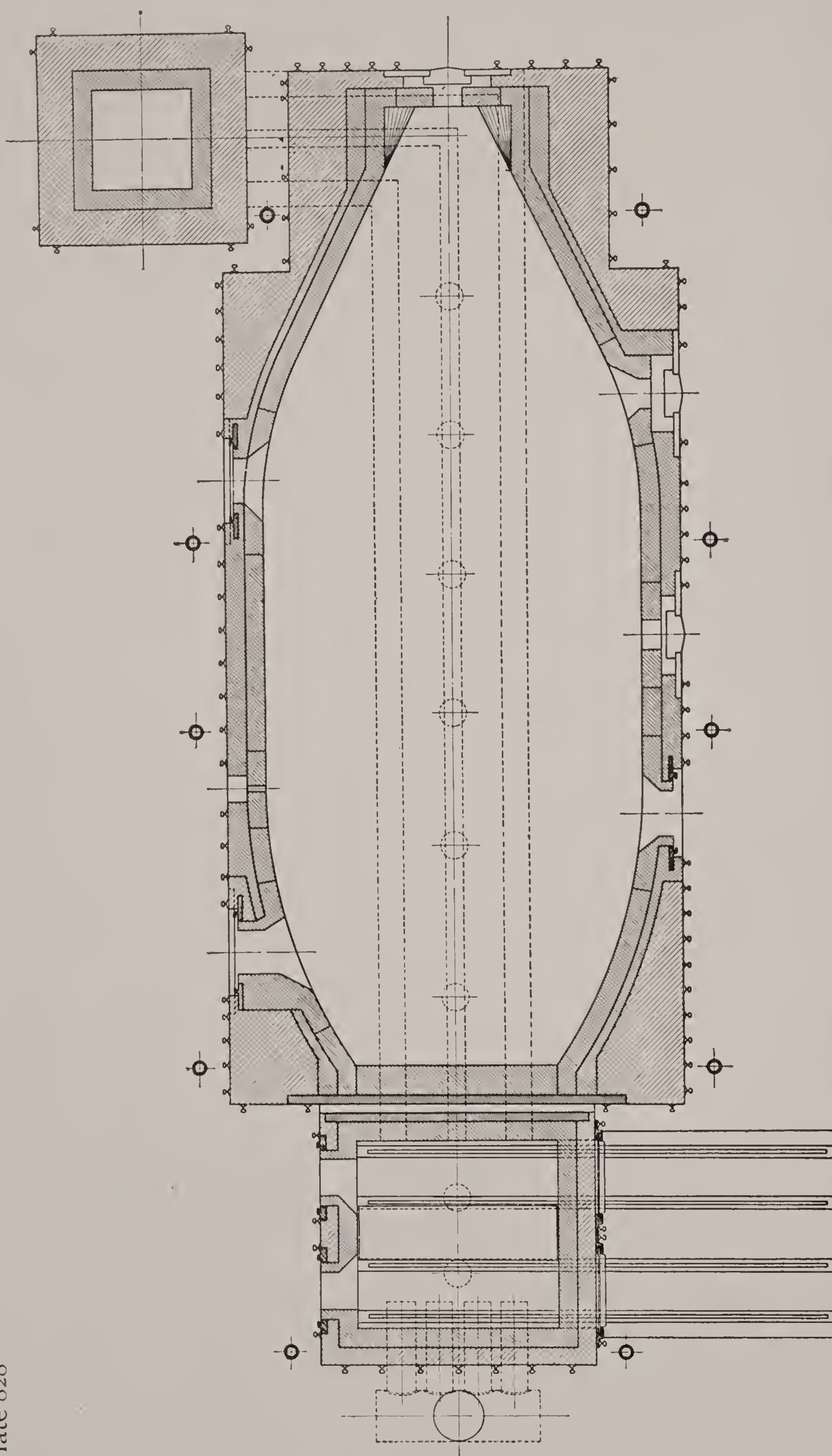
Roughly speaking, we may say that in large lead smelting plants where the ores can be made self-fluxing, the cost per ton of ore is about $4.50, and for ores which require considerable fluxing, about $7.00.

In large copper matting plants, ore can be smelted to matte under favorable conditions for $3.50. It will be readily understood that the cost of smelting in a large furnace is very much less (sometimes 50%) than in a small one.

REVERBERATORY SMELTING FURNACES

The old English reverberatory used for matting copper ores, would hardly be recognized in the large modern American furnace which is its offspring.

This type of furnace is largely used in the United States, and to show the general appearance and construction of a very large one of the latest design, we introduce Plates 827 and 828, which are reductions of the plan and elevation of one recently built by us; it has a smelting hearth 37½ ft. long by 15 ft. wide, the length over all being 54 ft. The furnace is provided with three steel double charging hoppers for ore and one steel double hopper for coal; the hoppers have telescopic necks which are pulled down when charging, to prevent dust. The fire-box is provided with blast pipe; the ash pans are two cars resting on rails which are lifted out of the ash pit bodily and run out on a track to the dumping ground.

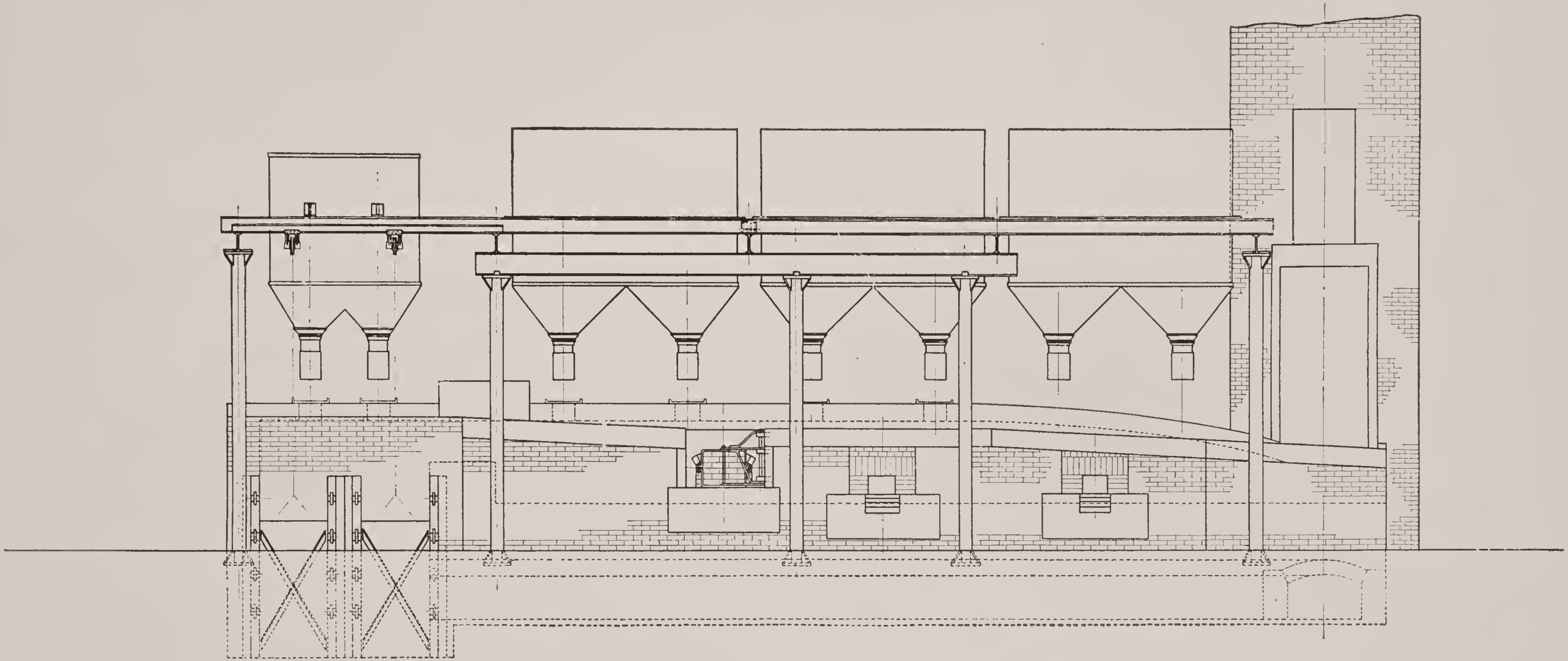


Plan

Large Reverberatory Smelting Furnace

Plate 828

Plate 827



Elevation

Large Reverberatory Smelting Furnace

DISPOSITION OF SLAG

The disposition of slag in large smelting plants is a matter of considerable importance. If possible, the smelter site should be so selected as to permit of an extensive slag dump; when, however, such ground is not available and the furnaces have to be placed on level ground, the disposition of slag is troublesome and expensive.

We will mention a few ways by which slag may be disposed of:

1. At a certain smelter in Mexico, the molten slag is cast into large bricks (the work being done by natives under contract), and the brick used for walls, buildings, drains and, in fact, for any purpose for which ordinary bricks can be employed. The bricks are large, about the size of an "adobe".

2. Slag can be advantageously used for "plating" the furnace yard, thus making a hard level surface for slag pots, also upon which to break up matte. The plates, made of molten slag, are blocks 3 to 4 feet square by about 8 inches thick.

3. Where water is available, slag can be granulated and sluiced to a distance.

4. When a dump is available, but at some distance from the furnace, molten slag may be transported in a large bowl mounted on a four-wheel truck; upon arrival at the edge of the dump it is poured out. These large slag trucks are drawn either by animals, a locomotive, an electric motor, or by a wire rope. They may be filled directly from the fore-hearth, or from ordinary slag pots when it is desired to save slag shells, the slag being drawn from a tap-hole in the side of the bowl. This method is practiced at many large smelters.

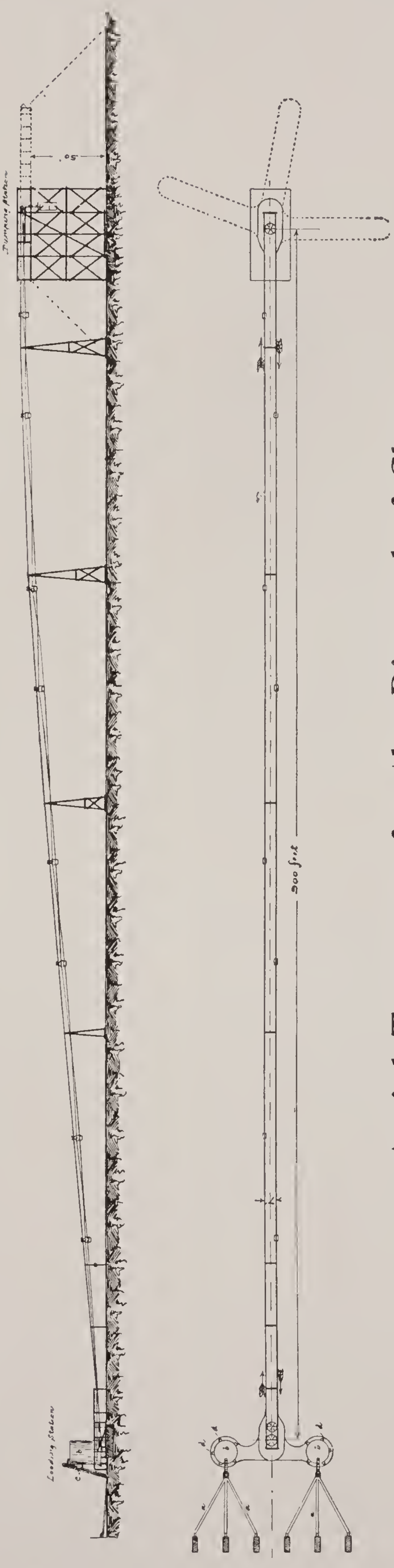


Plate S72

Aerial Tramway for the Disposal of Slag

System adapted to a smelting plant located on level ground; capacity 800 tons in 24 hours

Plate 782 illustrates a car we have especially designed for this purpose. It consists of an oval bowl of 35 cubic feet capacity, suspended by trunnions on two flanged wheels which roll on two bent rails placed at right angles to the truck. The truck frame is made of 5-inch steel channels supported on four car wheels 30 inches in diameter. At each end there is a platform, brake, spring buffers and connecting links for coupling.

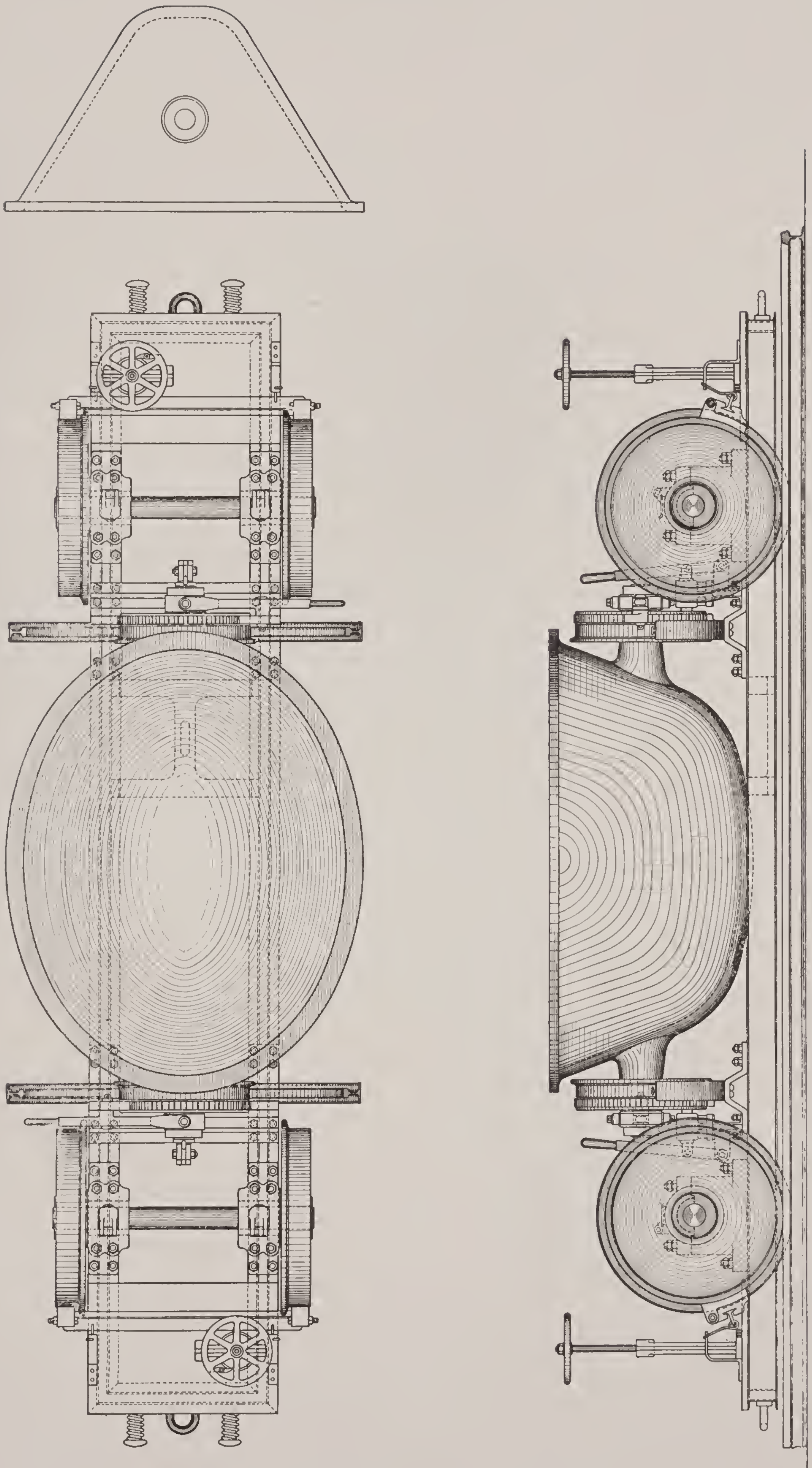
The bowl is nicely balanced, so that when full of slag very little power is required to tip it over. At each end there is a steel pin worked by a lever which, when pushed into a hole in the wheel supporting the bowl, holds it securely in position. All nuts are double. In fact nothing has been spared to make this car as perfect as possible.

Plate 815 and 816 illustrate another design of car used for the same purpose; the bowl is round and has a capacity of 25 cubic feet.

5. Granulated slag may be transported to a considerable distance by means of an aerial tramway, a method extensively used in Europe.

Plate 872 shows our arrangement of a tramway for removing 800 tons of slag per day from a large smelter located on level ground. The granulated slag is raised by an elevator to a storage bin from which the tramway buckets are loaded.

The six small rectangles shown in the cut indicate the blast furnaces.



Slag Car with Oval Bowl

Capacity 35 cubic feet

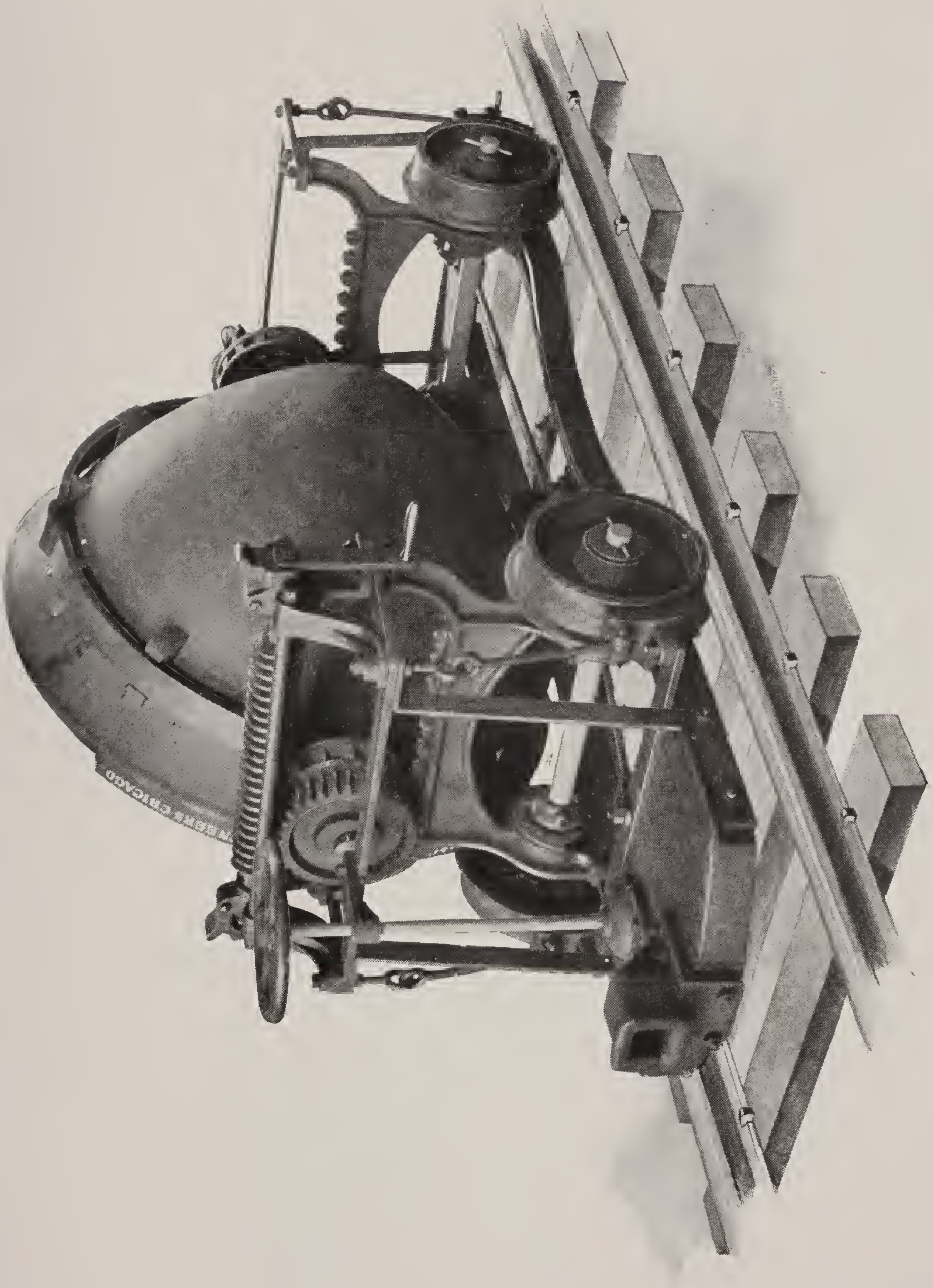
Plate 782

6. It has been suggested that granulated slag be blown through a pipe as is "culm".

7. Slag is often sold to railroad companies for ballast and in this way considerable profit is realized from this material.

Considerable material, such as slag shells, furnace breakings and matte, have to be re-smelted, and to raise this material to the feed-floor, certain machinery is required. For this purpose a platform elevator may be used, or an inclined railway called a "slag-hoist".

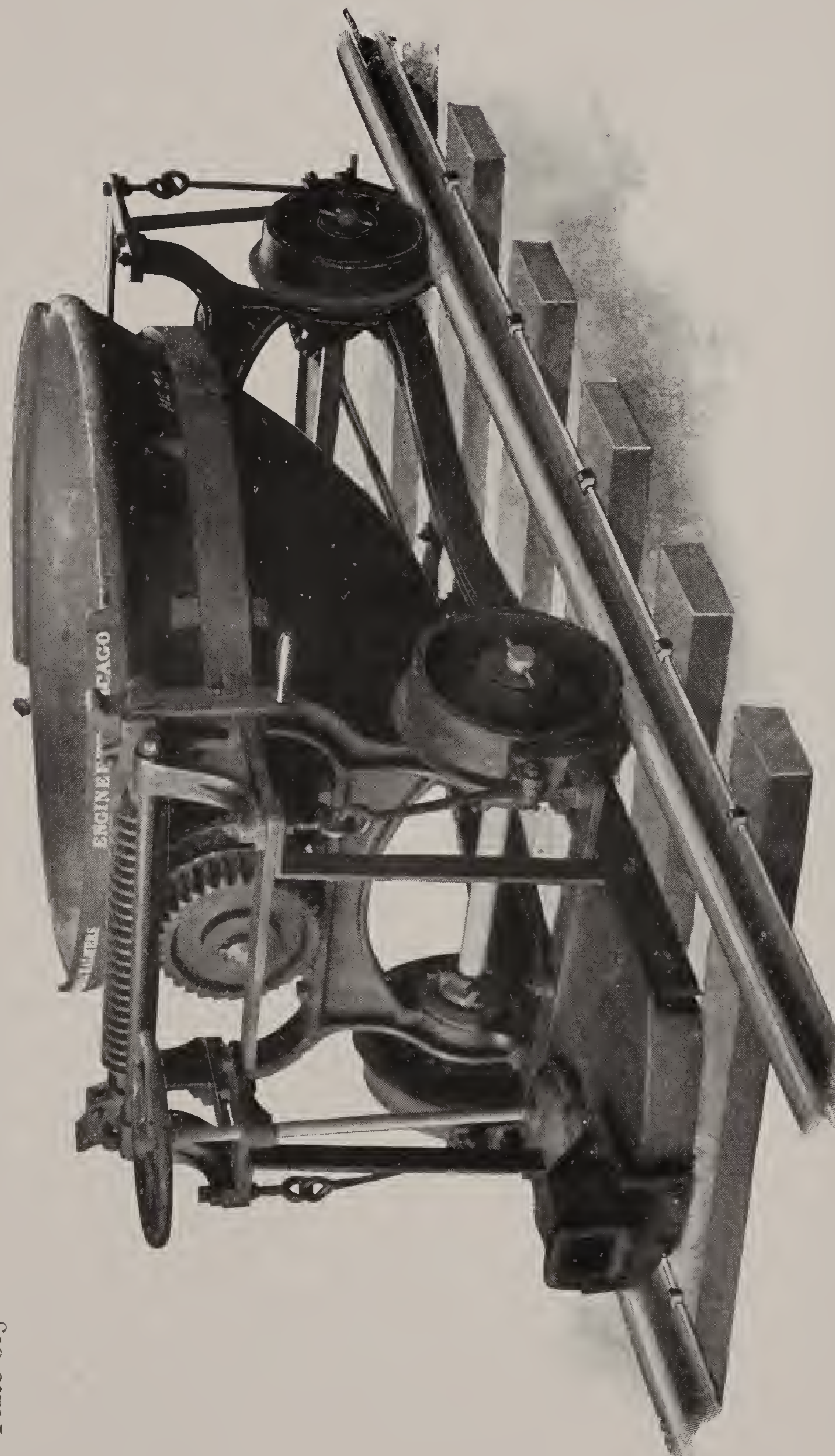
The slag-hoist comprises an inclined track which starts from the dump and terminates above storage bins located above the feed-floor; on this track runs an automatic dumping car drawn by wire rope operated by a belt-driven friction hoist. Such a railway has sufficient capacity for several furnaces.



Slag Car with Round Bowl

Capacity 25 cubic feet. Position of bowl when slag is being poured out

Plate 816



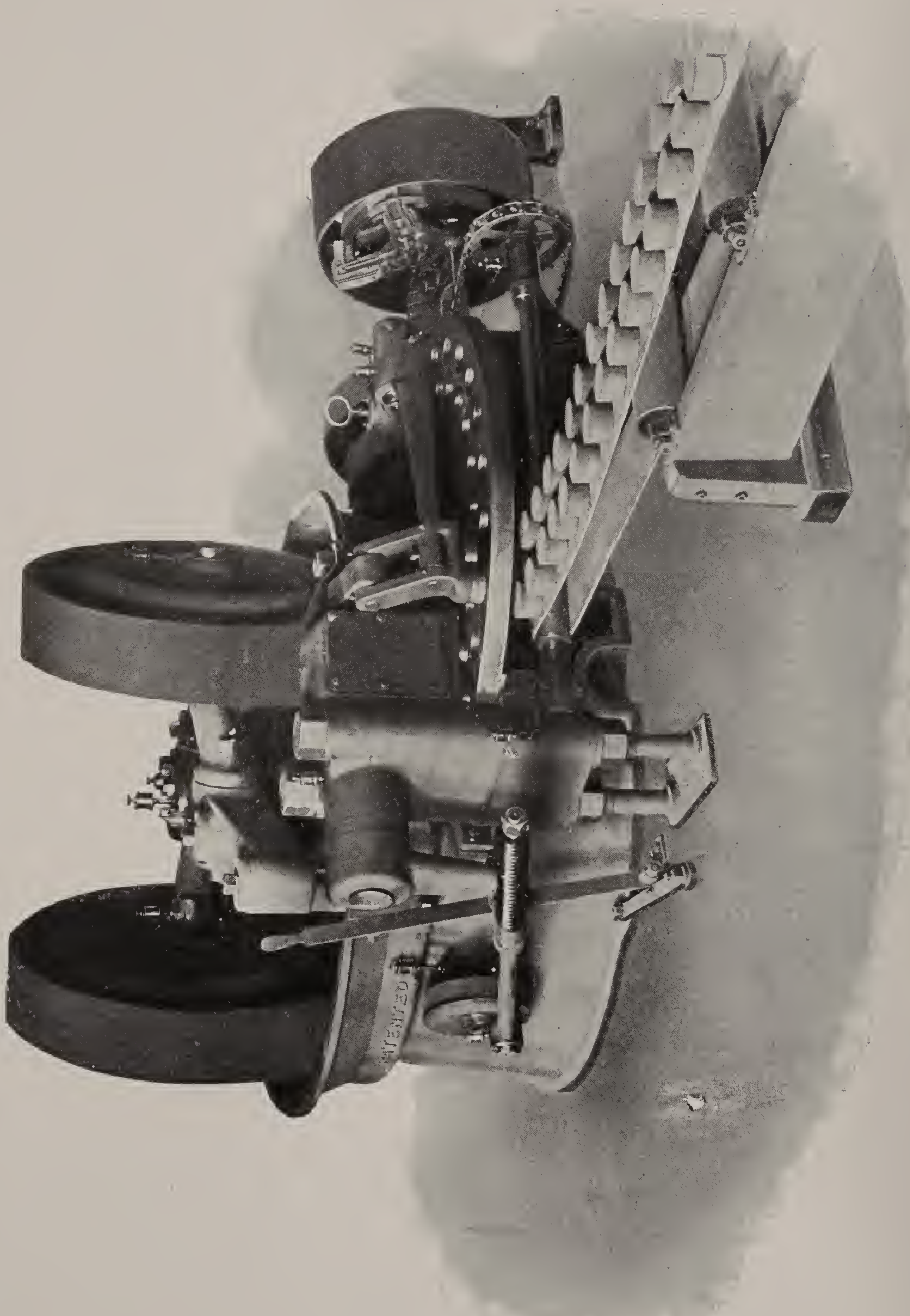
Slag Car with Round Bowl
Capacity 25 cubic feet

Plate 815

SEPARATION OF MATTE FROM SLAG

When a furnace is large enough to yield a continuous flow of slag the separation of matte from slag may be performed inside of the furnace by using Mathewson's slag tap, which is a detachable forehearth bolted to the furnace jacket. By this arrangement the blast is trapped, the slag overflows continuously, and the matte is tapped at intervals from a lower level.

Separation is made outside of the furnace in settling pots, which are large slag pots (see Plate 845); in forehearths (Plate 801); or in a reverberatory forehearth, which is a deep reverberatory hearth connected with a fire-box; into this hearth the slag and matte run directly from the furnace and remain there long enough for a clean separation to take place.



Improved Mineral Press

Plate 833

THE BRICKING OF FINE ORE

In a smelting plant there is always more or less flue-dust and fine ores to be smelted, but to charge such material directly into the blast furnace would cause much trouble; it chokes the furnace, causes irregularity, lessens its capacity, and sometimes it will even sift through the charge and pour through the tuyere openings but slightly changed. To avoid this evil, it is customary to mix this fine ore with clay, or preferably with lime, as the latter generally has a desirable effect in subsequent smelting; it is then molded into bricks which, after being dried or burnt in a kiln, can be satisfactorily smelted similar to any lump ore.

The best machine on the market for bricking ores, and one largely used, is the "Improved Briquetting Mineral Press" shown in Plate 833. It consists of a Chile Mill having two rollers 48 inches diameter by 12 inches face, each weighing 5,000 lbs., which revolve in a pan, part of the bottom of which is formed by a perforated disc or diaphragm, the latter being made to revolve slowly.

Fine ore, or flue-dust, mixed with the proper quantity of bonding material is fed into the pan; the rollers press it into the cylindrical openings in the revolving disc, and as each successive pair of molds or openings filled with solid briquettes (subjected to very considerable pressure under the ponderous rollers) pass out of the pan, they stop directly under the plungers of a "re-press" where a second or finishing pressure is applied; then passing on a little further, they are met by a pair of plungers which force them out of the disc and on to an endless belt.

The complete bricking plant comprises the press, a mixer for preparing milk of lime, a mixer for mixing the milk of lime with the ore and conveying it to the press, and an automatic feeder. Plate 833 shows the press only.

Bricks made with this machine are very hard and withstand breakage even when dropped from a height of several feet.

Parties contemplating the purchase of this valuable accessory to a smelting plant will find the following data of value:

The press is 6 ft. 2 in. high over all and occupies a floor space 9 ft. 6 in. x 11 ft. 6 in.

The machine should rest on a pier of masonry.

The machine is started and stopped by means of a lever connected with a friction-clutch pulley.

The capacity is 80 bricks per minute, the tonnage per day of ten hours varying according to the character and weight of the material.

To operate the press and accessories, 35 horsepower is required.

The gross shipping weight of the press and accessories is about 50,000 pounds.

Refining

COPPER CONVERTING
COPPER REFINING
CUPELLATION
LEAD REFINING

COPPER CONVERTING

BRIEF DESCRIPTION OF THE PROCESS

To bessemerize copper matte, which consists principally of copper, iron and sulphur, is to convert it into metallic copper by burning off its sulphur and slagging off its iron contents.

The process is conducted in a steel vessel called a converter, similar to that used for making bessemer steel. The converter has a thick lining of crushed quartz mixed with a sufficient quantity of clay to hold the quartz together; near the bottom of the converter is attached a wind-box which supplies air to a number of horizontal tuyeres, these being simply holes pierced through the lining. Molten copper matte is charged into the converter in quantity equal to its capacity (from 3 to 10 tons), and air from a blowing engine under a pressure of from 6 to 15 lbs. is forced through the molten mass. The sulphur combines with the oxygen of the air forming sulphurous acid gas, which passes off while the iron is oxidized and unites with the quartz of the lining to form a slag; the slag is poured or skimmed off and returned to the blast furnace, and the metallic copper is poured out into molds. No fuel is used in this operation, the heat being supplied by the combustion of the sulphur in the matte.

Usually, mattes are not bessemerized which contain less than 45 per cent. copper, and they are "blown" to blister copper in one operation.

Lower grade mattes corrode the lining too rapidly, and high grade mattes (60 per cent. and higher) do not furnish sufficient heat by their oxidation.

The following typical figures taken from "Modern Copper Smelting" serve to illustrate the composition of the matte, slag, copper, etc.:

Matte.			Slag Produced. 1.	2.
Copper, . .	51 per cent.	Silica, ...	41.90	35.70
Iron, . . .	22 "	Ferrous oxide,	48.06	55.83
Sulphur, .	26 "	Copper, . . .	1.00	2.00

Blister copper produced, 99 per cent.

		Converter Lining. For Body or Shell.	For Top.
Parts by volume	Clay, ...	17	28
	Quartz, ...	83	72
		100	100

From the above figures, it will be seen that the lining is rapidly eaten out, in fact that the operation is performed at the expense of the lining, and that the process differs very materially from the bessemer process as applied to steel making, the former requiring 50 per cent. of its contents to become oxidized, while the latter requires from 3 to 5 per cent.

Bessemerizing copper mattes was first practiced in the United States in 1884, since which time we have been large builders of converting machinery, having furnished such machinery to the Anaconda Smelting Works, Copper Queen, United Verde, Nichols Chemical Co., Arizona Copper Co., Mount Lyell Mining & Railway Co. of Tasmania, and others.

COPPER-CONVERTING MACHINERY

CONVERTERS

Copper converters are of different shapes and sizes, though in general appearance they are more or less similar to the vessel used for bessemerizing iron. They may be divided into three types: The round or "Parrot" converter, Fig. 788, used by the Anaconda Co. and others; the square or "Stalmann" converter, Fig. 787, used by the Mt. Lyell Mining & Railway Company of Tasmania, the Mazapil Copper Company of Mexico and others, and the trough or "Bisbee" converter, Fig. 785, used by the Copper Queen Mining Company, Arizona Copper Company and others.

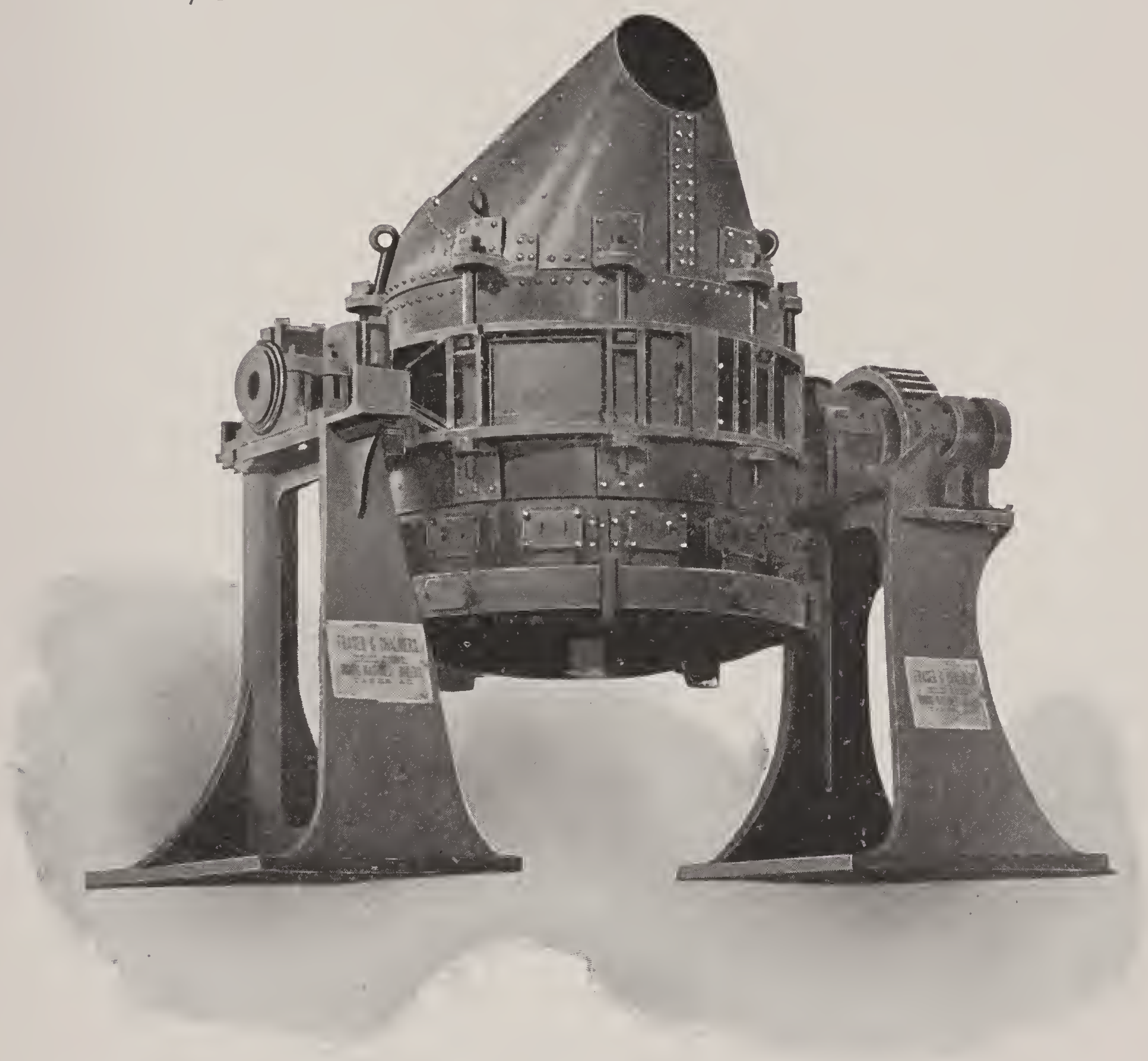
Converter shells are made of heavy steel plates riveted together. They are supported either on trunnions or rollers, and are tilted by hydraulic machinery. For convenience in re-lining, the top is separable from the body, and in the Parrot the shell is separable into four sections.

The capacity of converters may vary from 3 to 10 tons, the capacity of a newly lined converter being less than it is after several "blows", as the lining is being continually eaten away.

The following table taken from "Modern Copper Smelting" gives details of the size, capacity, etc., of different converters:

COMPANY.	Outside Height, feet.	Outside Diameter, feet.	Blast Preserve, lbs. per sq. in.	Initial Charge, lbs.	Maximum Charge, lbs.	Blows per 24 hrs.	Weight of Shell and Lining.	Number of Tuyeres
Parrot & Montana Ore Purchasing Companies.	8.5	5	11	2500	9000	16	16000	16
New Anaconda..........	10	6	13	7000	17000	12	22000	16
Great Falls..	13	7	16	10000	22000	10	26000	18
Stalmann...............	8	5	10	3000	9000	14	17000	10
Copper Queen..........	17 25	5.67x8	5.5	4000	10000	12	.....	11

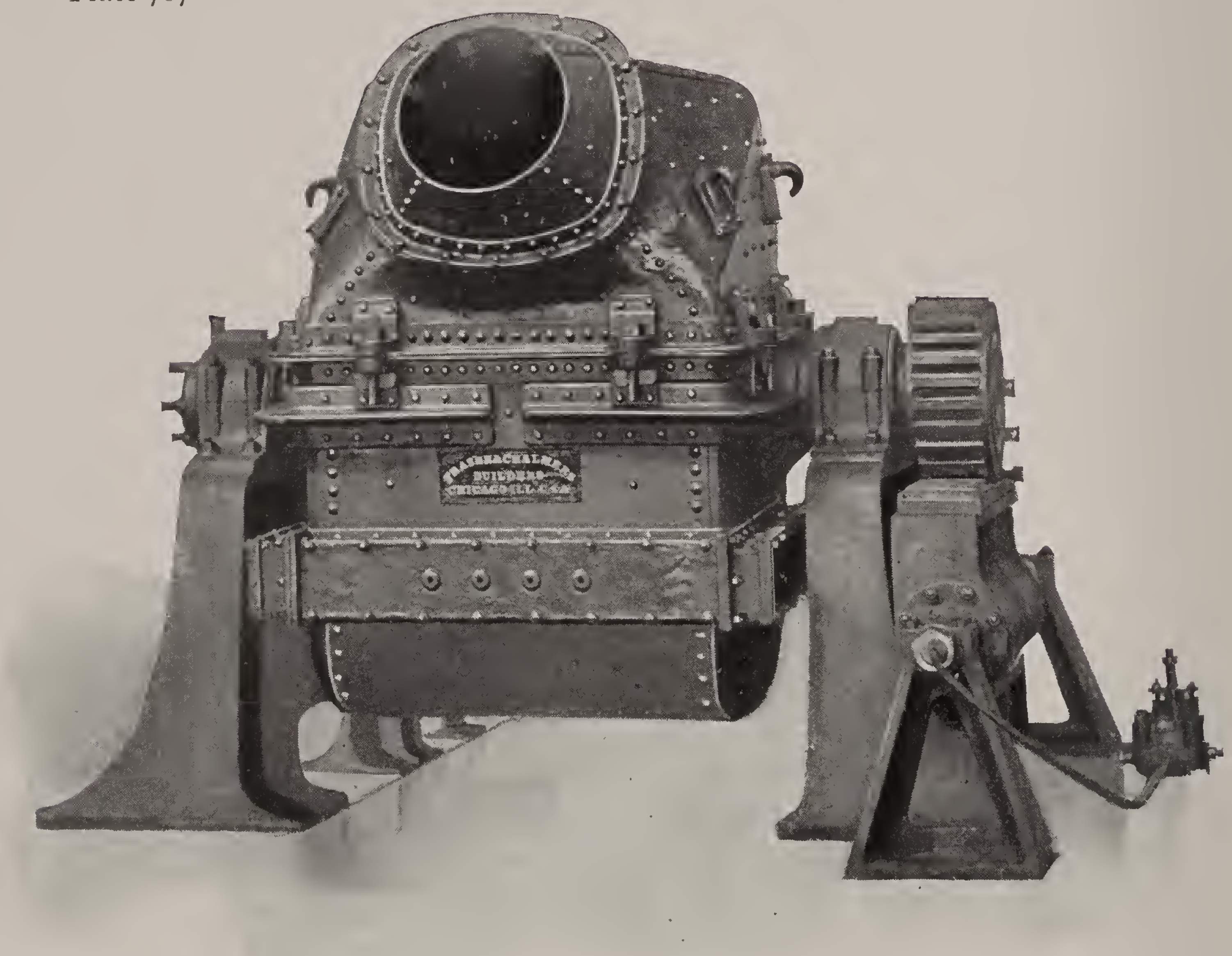
Plate 788



The Parrot Converter

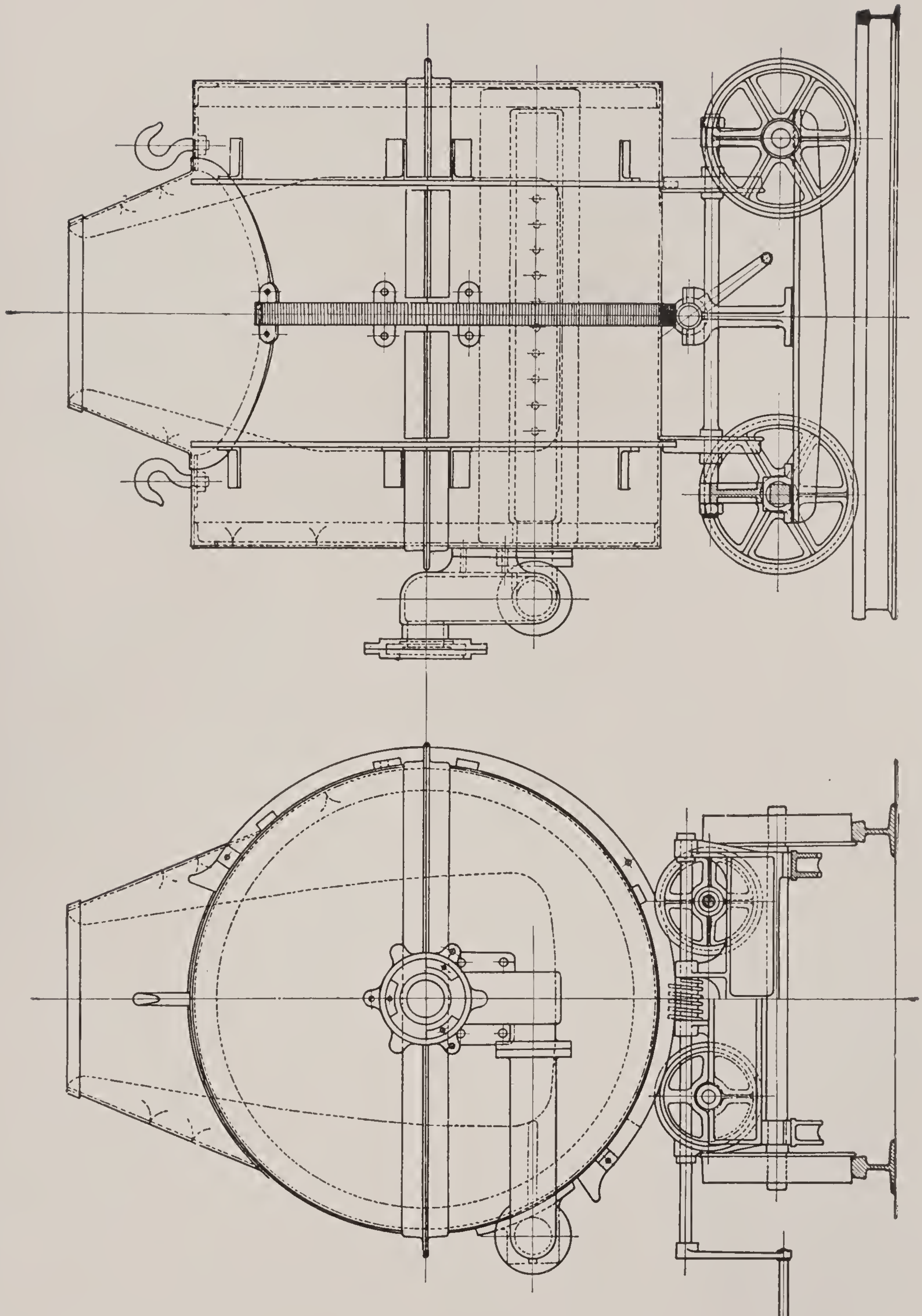
Round Type used by Anaconda Co. and others

Plate 787



The Stalmann Converter

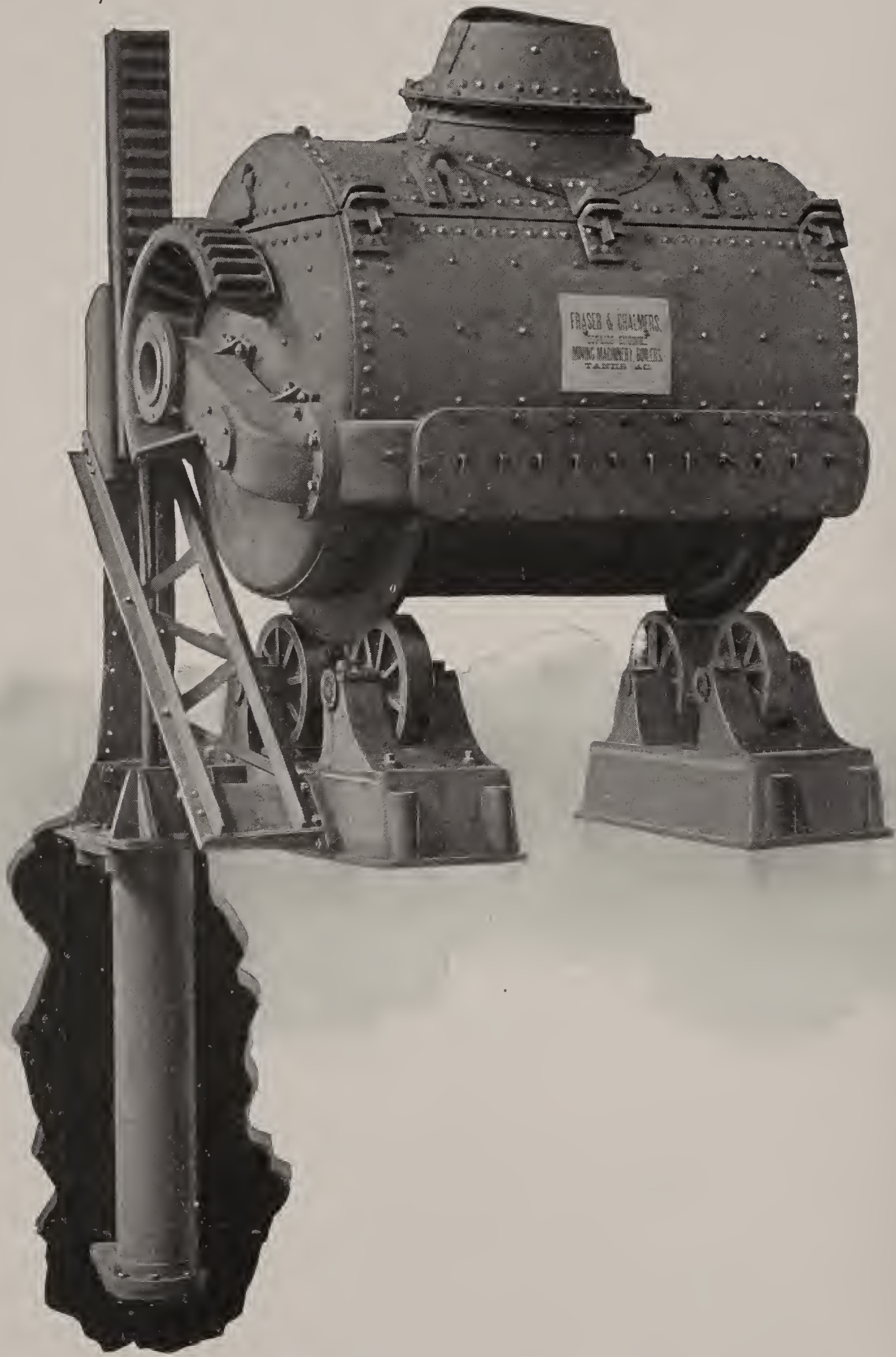
Square Type used by Mt. Lyell Mining & Railway Co. and others



Small Cylindrical Converter

Plate 829

Plate 786



The Bisbee Converter

Cylindrical Type used by Copper Queen Mining Co. and others

THE BISBEE CONVERTER

The mechanism for tilting the converter consists of a vertical rack (Plate 786) or horizontal rack (shown in Plate 787), operated by a hydraulic cylinder, this rack engaging a pinion centered with the axis of the converter.

The cylindrical or Leghorn type of converter is the most popular. The advantage of the trough or cylindrical shape is that when slowly tilting the converter during "blowing," air is made to pass through the upper layer of copper matte without disturbing the reduced copper below it, which requires no further action of the air. The depth of material being less than in the other types of converters less blast pressure is required.

This converter is supported in the best manner to reduce friction to a minimum, viz., on four friction rollers on which two steel riding rings, which partly encompass the cylinder, bear. The rack being vertical leaves the space around the converter clear. Such satisfactory results are obtained with this style of converter that it is being almost universally adopted.

EXPERIMENTAL CONVERTER

For experimental purposes we manufacture a small "trough" converter mounted on a car, with hand-tilting mechanism; the capacity of this converter is from ¾ to 1¼ tons. Plate 829 shows its general appearance.

HYDRAULIC MACHINERY

In converting plants, hydraulic power may be used for tilting converters, for operating cars used for transferring converter shells to and from the re-lining station, and for operating the truck which carries the ingot molds into which blister copper is poured after the charge has been "blown."

In large plants an electric traveling crane has taken the place of the hydraulic transfer car.

For tilting converters, a water pressure from 175 to 500 pounds is used. When local conditions permit, the simplest method for obtaining this pressure is by pumping water into a tank placed considerably higher than the "bessemer pit", and letting the water flow back by gravity to the hydraulic mechanism. This method is especially applicable where the cylindrical converter is used, as a height of about 400 feet will give a pressure of 175 pounds, which is sufficient for tilting this converter.

A second method for obtaining hydraulic pressure, is by using an accumulator into which water is pumped under high pressure by a pressure pump. The accumulator is a vertical cylinder provided with a weighted piston. This apparatus is shown in Plate 784, which is a photo-engraving of one sold to the Mt. Lyell Mining & Railway Company of Tasmania.

The pressure obtained with this apparatus is regular and uniform, and no jerking motion is imparted to the converter while it is turning. A governor attached to the pump, stops it when the piston has reached its maximum height.

Plate 778 shows apparatus used for obtaining hydraulic pressure by a third and cheaper method, viz., a closed steel tank placed over an open steel tank, together with the necessary high pressure pump. The closed tank is provided with pressure gauge and pop safety valve, and the pump with an automatic speed regulator, which adjusts the speed of the pump to the pressure required.

ELECTRIC CRANE

For moving converter shells from their hydraulic stands to the re-lining station, either an electric traveling crane or a hydraulic transfer car is employed. When the finances of the company permit, the crane is used, as by this means all the lifting and transferring operations of a bessemer plant other than the tilting of the converters can be effected. The crane is provided with three independent motors—one for each movement and sometimes with an additional motor for tilting the ladle.

Plate 784

Hydraulic Accumulator

Open Tank and Pressure Pump

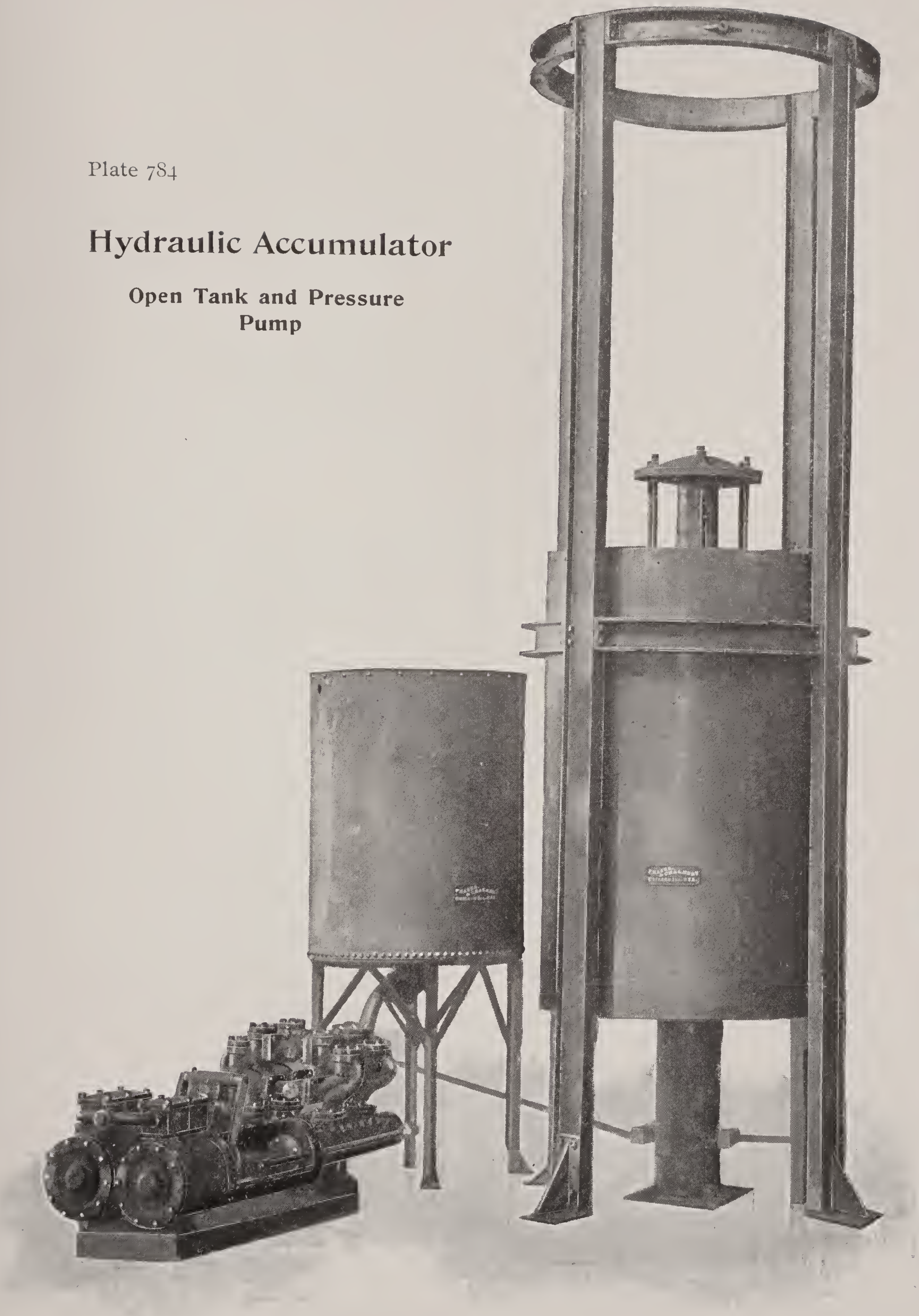
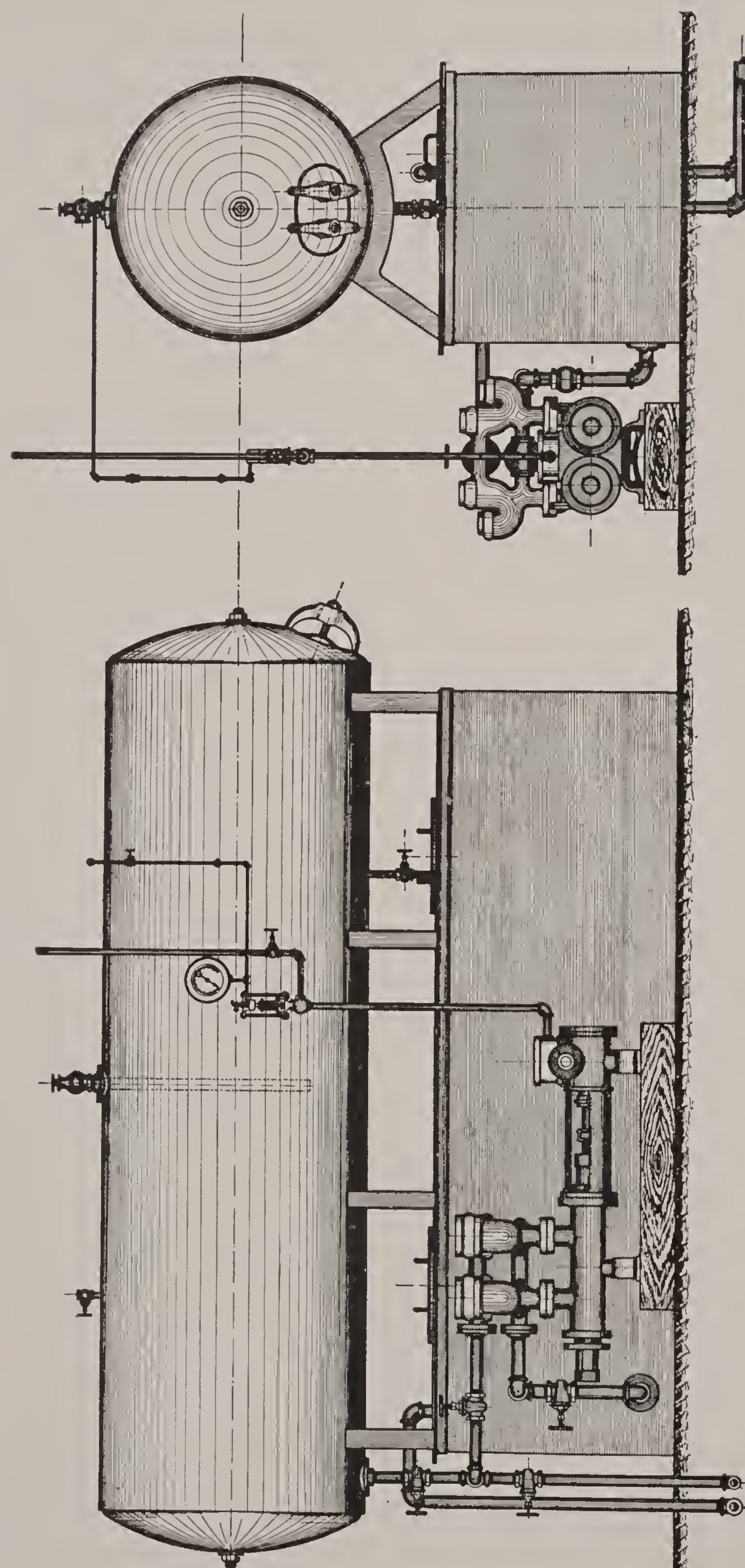


Plate 778



Pressure Tank and Accessories

HYDRAULIC TRANSFER CAR

Plate 802 shows a hydraulic transfer car which is simply a hydraulic jack mounted on a four-wheel truck which runs on rails. By means of such a car with proper tracks and turn-tables the converter shells can be moved to any part of the building. Plate 785 (page 147) shows a converter shell, transfer car and turn-table.

We sometimes furnish these cars with a hand pump attached to the carriage, which makes the apparatus independent of outside pipe connections.

ELECTRO-HYDRAULIC TRANSFER CAR

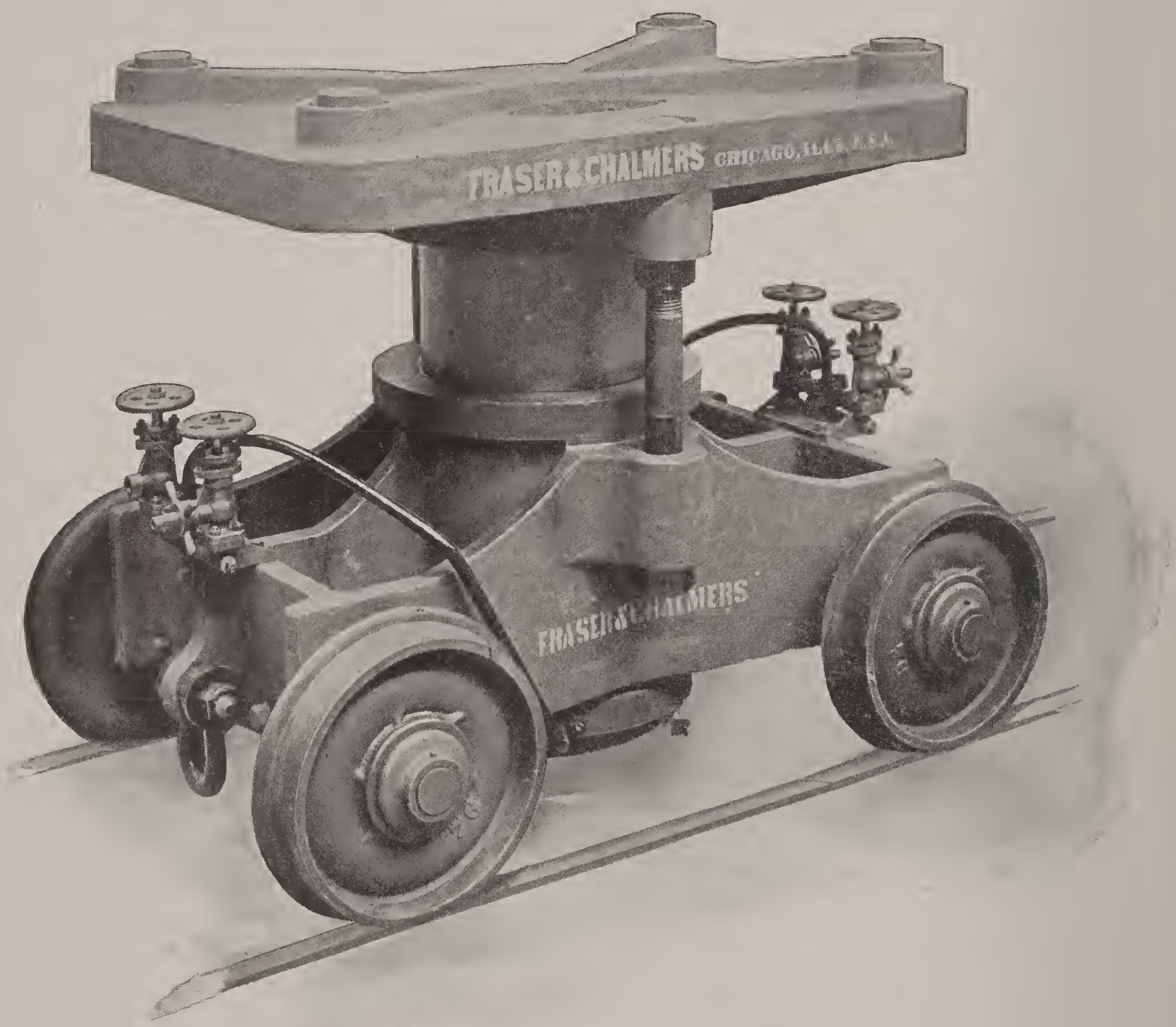
A car with its load weighs some 18 to 20 tons and is moved slowly and with difficulty. For use where electric power is available, we have designed a car which is propelled by a motor attached to the truck, the current being taken from an overhead wire.

INGOT MOLD TRUCKS

These trucks are platforms which hold the molds when they are pushed under the converter to receive the blister copper; they are made of steel beams supported on four wheels which run on the same track as the transfer car, when the latter is used. Plate 783 (page 148) shows such a carriage, the top of which is made in steps so as to preserve the same distance between the molds and the lip for the converter when the converter is being poured, this being done to prevent splashing of the copper.

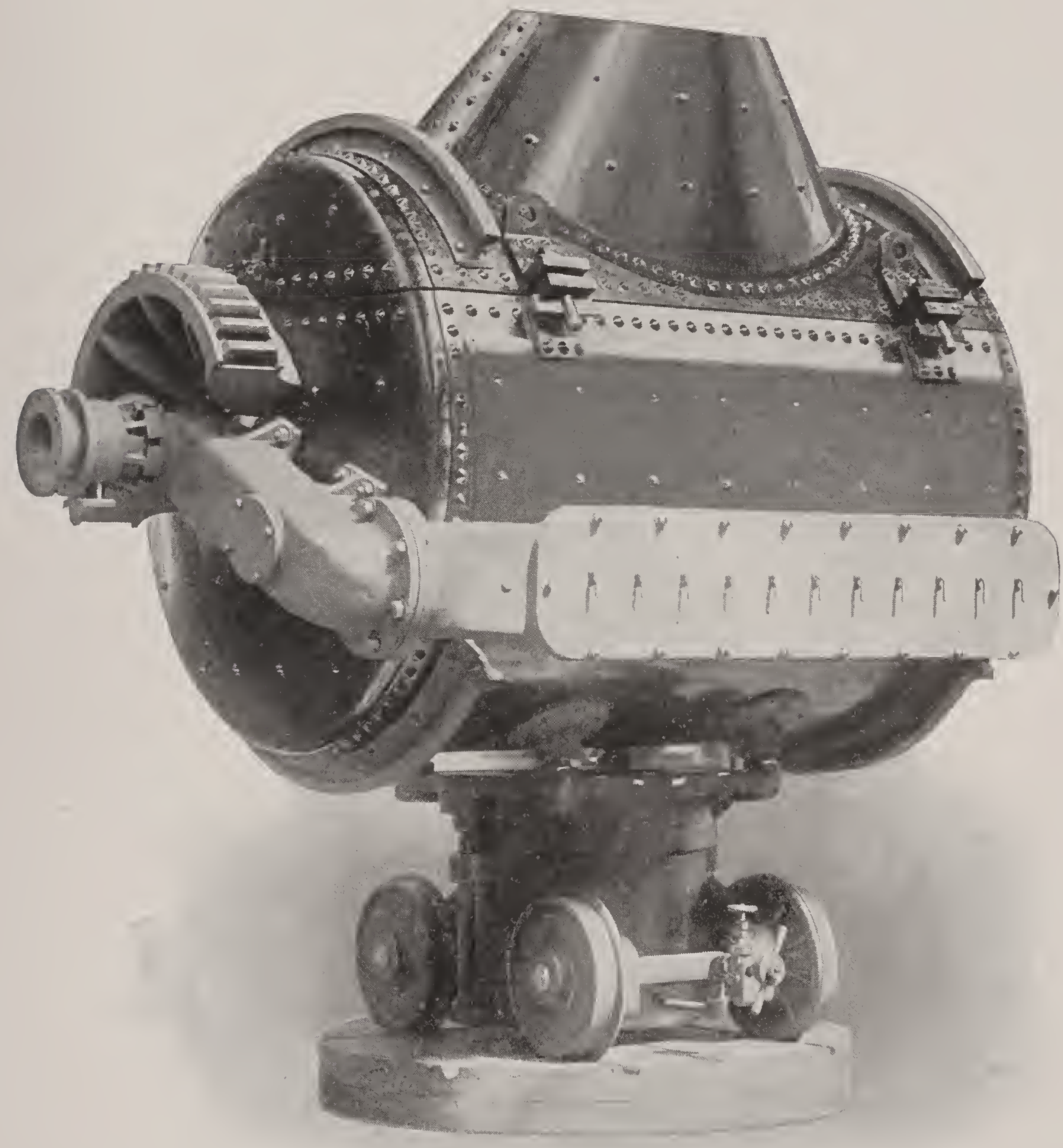
Plate 780 shows another design of an ingot mold truck moved by a hydraulic cylinder placed beneath the floor; we have recently furnished this type to the Arizona Copper Company, who find them very effective, they being much quicker, more adjustable, and saving hand labor to a greater extent than the ordinary truck.

Plate 802

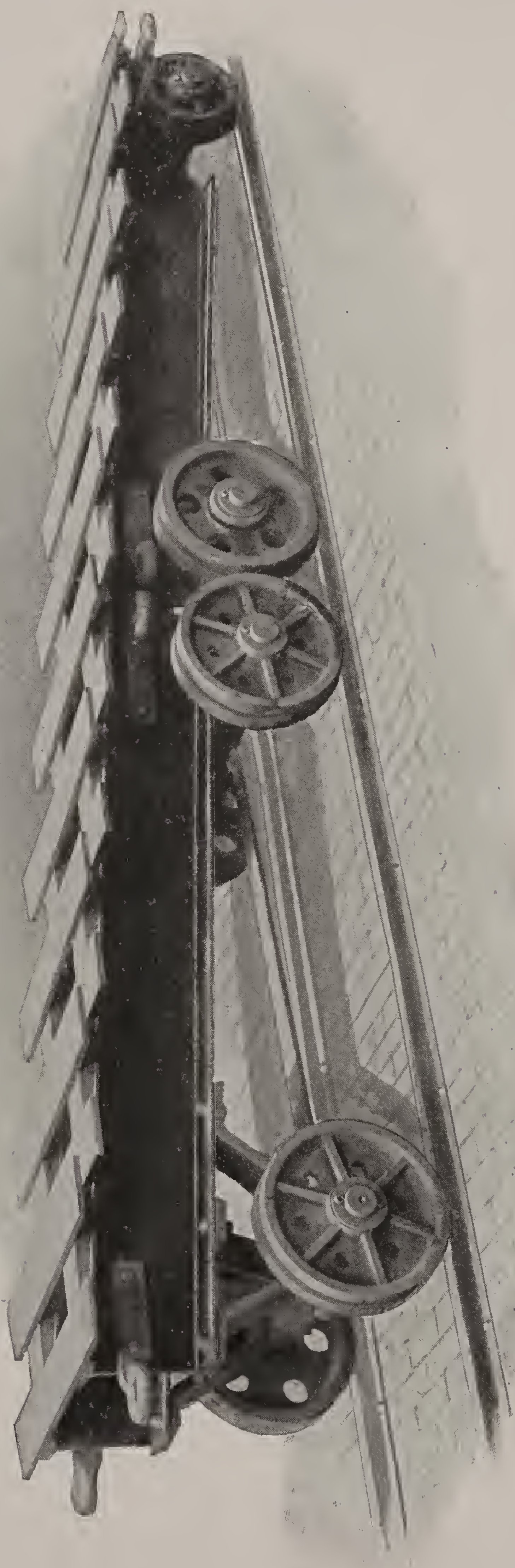


Hydraulic Transfer Car for Moving Converters

Plate 785



Hydraulic Transfer Car and Turn-table for Bisbee Converter



Ingot Mold Truck

Plate 783

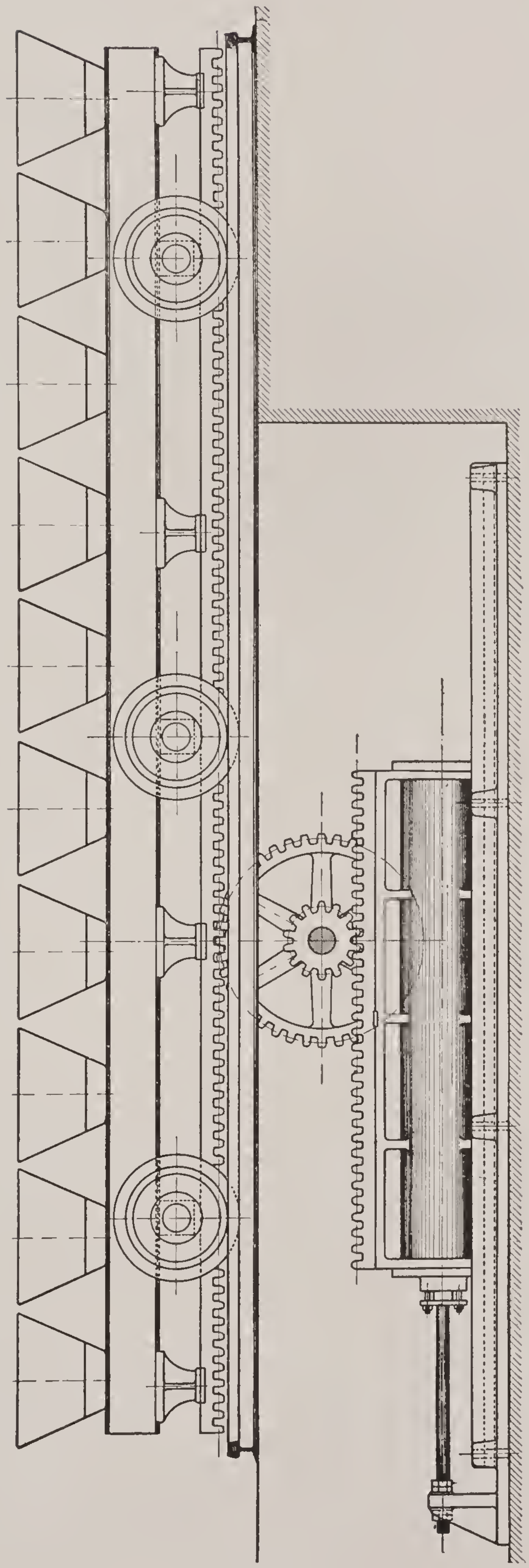


Plate 780

Ingot Mold Truck Moved by Hydraulic Power

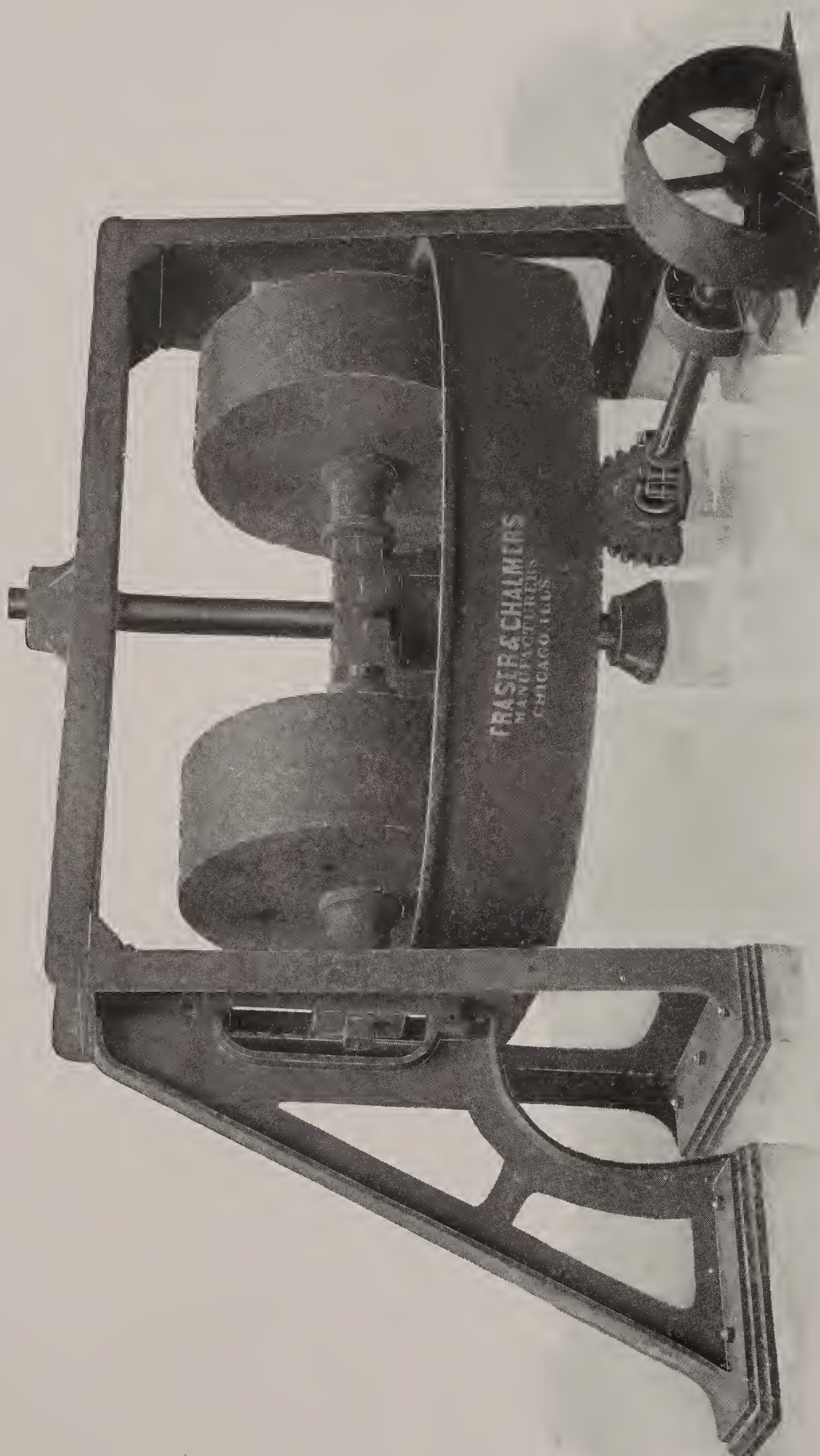


Plate 789

Chilian Mill for Grinding Clay for Lining Converters

BLOWING ENGINES

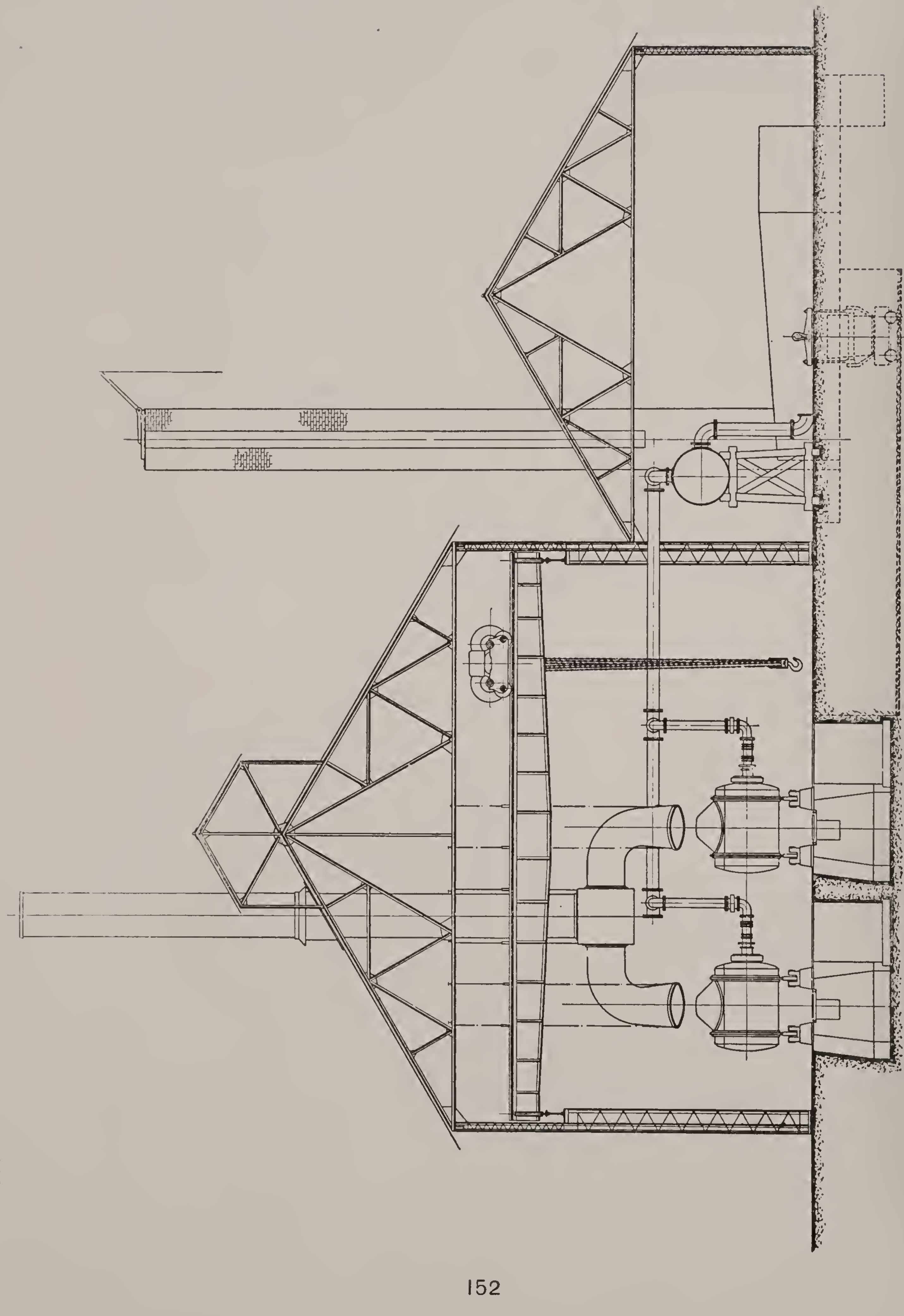
The cost of producing the blast is a very considerable item in bessemerizing matte, and to reduce this expense to a minimum an economical blowing engine should be used. For descriptions of blowing engines operated by steam, water-power or electricity, best suited for delivering air under pressure for "blowing" converters we refer you to our Riedler catalogue.

TRANSFERRING MATTE TO THE CONVERTER

In plants where the production of matte is large, the blast-furnaces are provided with large forehearths in which several tons of matte are allowed to accumulate. The quantity required for a converter charge is tapped from the forehearth into a ladle, which is then carried by an electric crane directly to the mouth of the converter, into which it is poured. In smaller plants a reverberatory furnace, or reverberatory forehearth located near the converters, is used, in which to store molten matte until it is required. When a converter charge is needed, it is tapped directly into the converter, or into a ladle. Cold matte may be melted in such a reverberatory or in a cupola, provided with a large movable well or crucible mounted on wheels.

CHILIAN MILL OR MORTAR MIXER

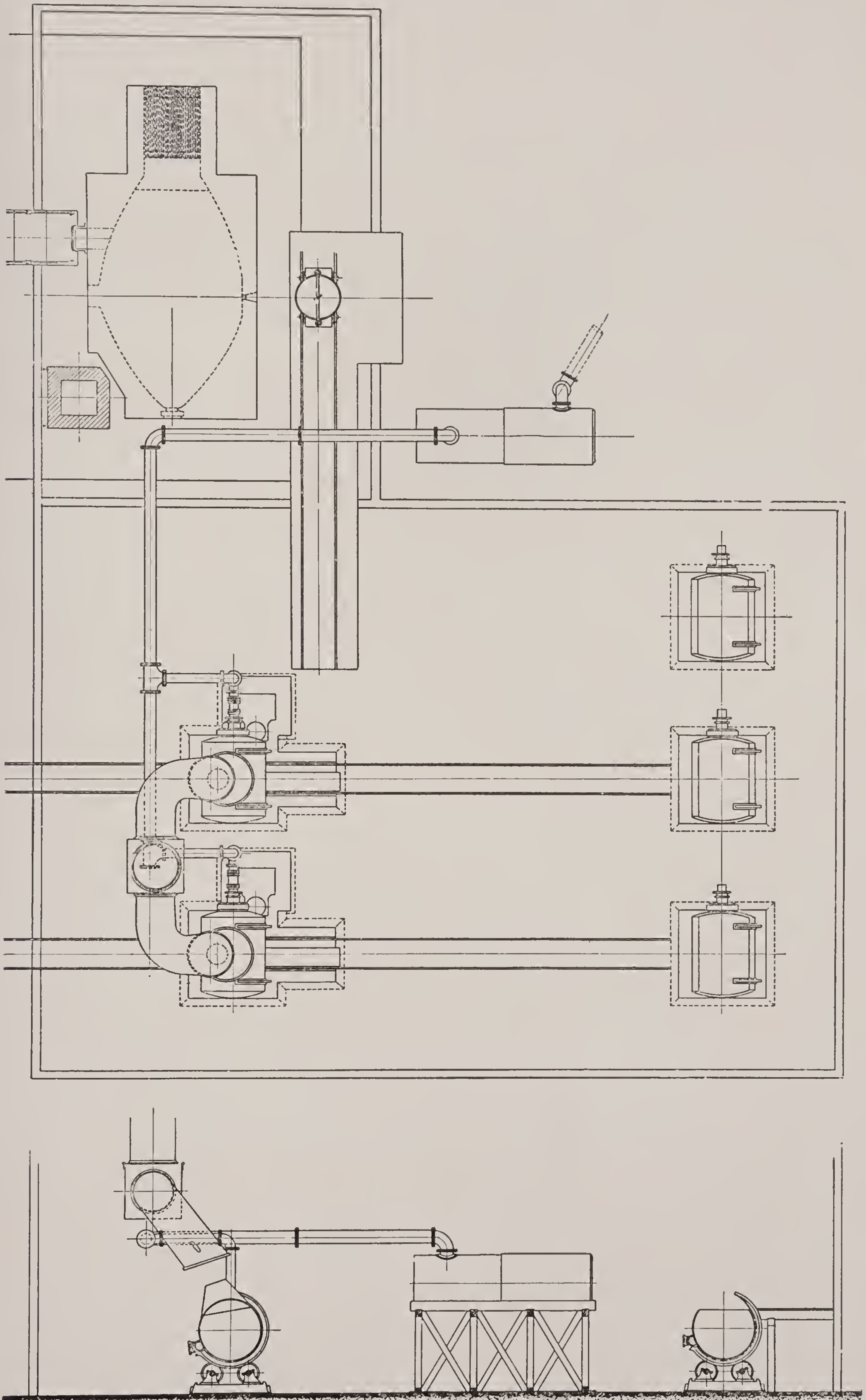
Fig. 789 shows the Chilian Mill or Mortar Mixer, which we have designed especially for grinding the material used for lining converters. It consists of a shallow iron pan in which are placed two heavy rollers supported in a self-contained cast-iron frame. The pan revolves while the rollers are held in a fixed position. The apparatus is so constructed that all the wearing parts—the-pan die, roller shells and roller bearings—can be readily replaced when worn.



Plant for Bessemerizing Copper Mattes

Elevation

Plate 777a



Plant for Bessemerizing Copper Mattes

Plan

Plate 777b

CONVERTING PLANTS

An illustration of a typical modern copper-converting plant is shown by Plates 777a and 777b, which are plan and elevation of a plant we recently built for the Arizona Copper Co. Ltd.

Everything about the plant is arranged for convenience and economy. The buildings are of steel construction and well ventilated. The converters, of which there are two "stands", are of the cylindrical or "Bisbee" pattern, and have a capacity of about five tons each. Handling of the converters is done by means of a 30-ton electric traveling crane. The matte is tapped from a reverberatory furnace into a ladle which rests on a 4-wheel truck; when the ladle is full, it is moved by a windlass to within reach of the crane, which then picks it up and pours the matte into either of the two converters. The ingot mold carriages are moved by hydraulic mechanism. The blowing engine is of the Riedler type, driven by four gas engines. The electric crane is operated from a central station on the floor of the bessemer-pit, so that the man in charge is not subjected to the fumes. Hydraulic pressure is obtained from a tank on the hill-side.

Engineers who have visited this plant consider it a model one, of which the Arizona Copper Company as the owners, and we as the builders, may justly feel proud.

COPPER REFINING

Crude copper obtained by smelting oxides and roasted sulphides in the blast furnace, or in the reverberatory, and blister copper from bessemerizing matte, contain from 1 to 3 per cent. of impurities (principally surphur, arsenic, etc.) which unfits them for commercial purposes. This impure copper is refined by subjecting it first to oxidation and afterwards to reduction in a reverberatory furnace, the method being known as the ordinary "Swansea" process.

The furnace used for this purpose is strongly built and thoroughly bound together; below the skimming door, which is at the chimney end, there is a heavy cast-iron plate; sometimes the entire bottom and sides of the furnace are incased in cast-iron plates.

Plate 840 shows the general appearance and construction of H. L. Bridgman's refining furnace, which is the outgrowth of his many years of practical experience in copper refining. We usually build this furnace to have a capacity of about 10 tons of copper. In strength and durability it is unsurpassed.

Formerly, refining furnaces were made to have a capacity of about 7 tons, but now in large plants they are sometimes made to hold as much as 15 tons.

The hearth of the refining furnace is made of white sand, carefully smelted in and saturated with copper to make a "bottom".

Wood is the best fuel, bituminous coal being secondary; coals containing sulphur should not be used.

Copper refining is a delicate operation requiring skilled labor. In ordinary cases the process takes 24 hours, the latter part of the operation being very laborious.

The process is for refining copper which already contains as much as 96 per cent. of copper; copper of lower grade being best subjected to a preliminary melting down with free admission of air in a blister furnace, which is of similar construction to the refinery, and then tapped out into pigs which will then be of suitable grade for refining.

The process of refining which comprises two stages—oxidation and reduction—may be briefly described as follows: The furnace being hot, ingots or bars of blister copper are charged through the side door by means of an iron paddle, the copper being piled up and distributed over the entire hearth. After charging, the fire is not strongly urged and air is admitted so that, as the ingots slowly melt down, oxidation will take place. After the copper is melted down it is skimmed free from slag.

The charge boils constantly owing to the escape of anhydrous sulphuric acid, which stirs up the molten mass even better than rabbling would, causing fresh surfaces to be presented for oxidation; suboxide of copper forms and exerts a powerful action upon the elements (chiefly metalloids), which exist in the copper as impurities and which have a greater affinity for oxygen than for copper.

Ebullition gradually ceases owing to the disappearance of most of the sulphur, and suboxide of copper then rapidly forms.

Sulphur clings to copper with great tenacity ; to eliminate the small quantity which still remains, flapping or rabbling the charge is resorted to, in order to constantly expose fresh portions to oxidation.

Finally, by the slow and tedious operation of rabbling and skimming, the injurious impurities are oxidized and removed either in the slag, or by volatilization. When this point (which is determined by physical examination of small test samples) has been reached, the oxidation stage is concluded.

We now have a bath of commercially pure copper, containing considerable suboxide; to convert the latter into metallic copper, reduction must be resorted to. This is effected by covering the surface with charcoal and burying a long pole of green wood in the molten copper; large volumes of hydrocarbons and other reducing gases are thus evolved, which rapidly remove the excess of oxygen. This process is termed "poling".

When all the suboxide has been reduced, test samples taken from the furnace show a fibrous texture and silky lustre of a rose-red color, and the sample ingot does not contract on cooling, that is, the top remains flat. The copper is then said to have reached its "pitch", and is ready for ladling.

Ladling is done as rapidly as possible, so as not to give the copper time to change its pitch; the fire should be previously attended to and everything arranged so that during ladling there will be an equally balanced oscillation between oxidizing and reducing action in the furnace.

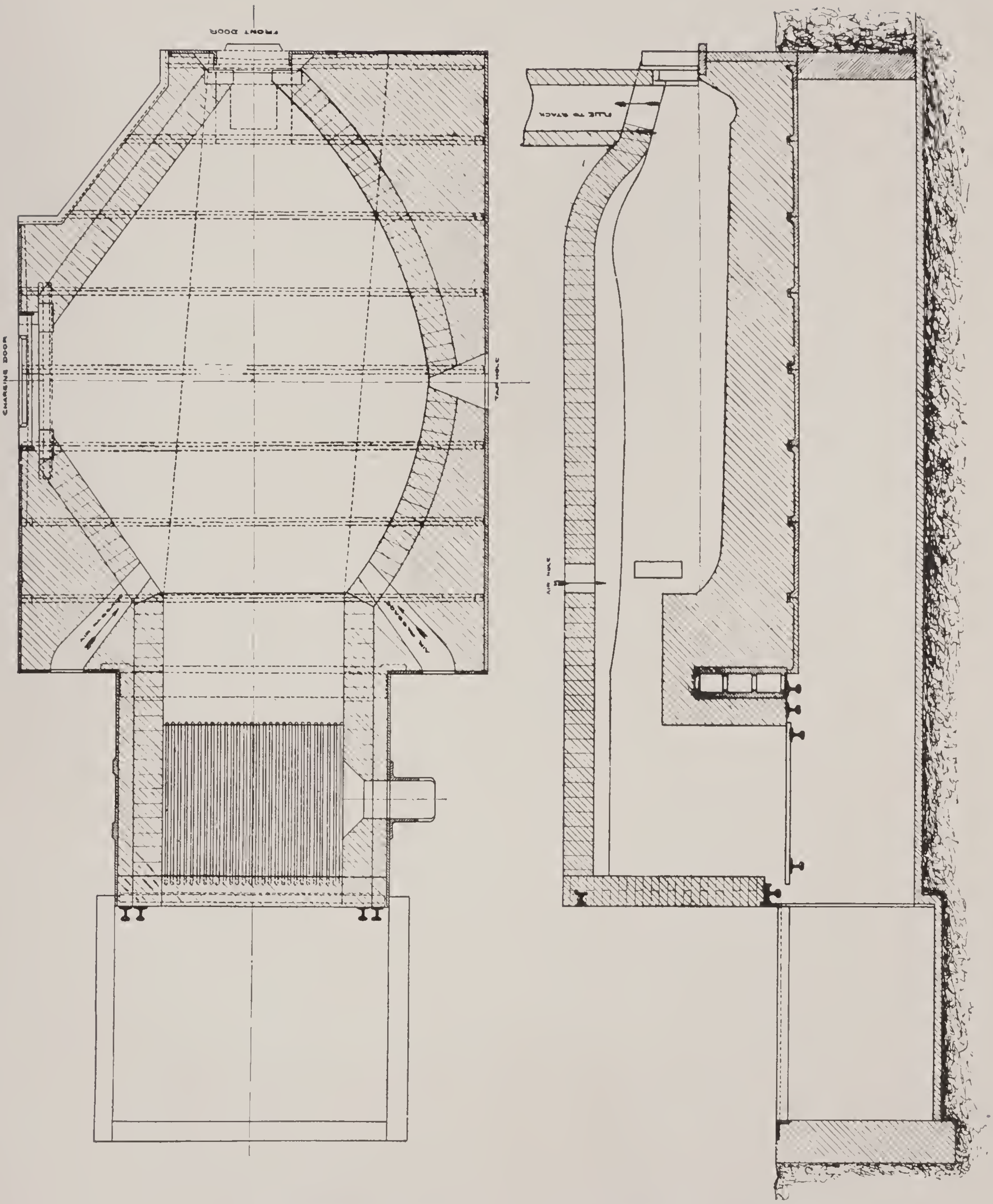
It takes very little to throw copper out of pitch, and any change is immediately shown by the appearance of the ingots. If on cooling, the ingots contract, leaving a depression in the center, it indicates that suboxide is forming, and ladling must be stopped and the charge poled a little; short sticks of green wood thrown on top of the copper assist in the reduction. If, on the other hand, the surface of the ingot rises and becomes convex, then the charcoal must be pushed back from the ladling door, and the charge flapped or rabbled. It only takes a few moments to bring the copper back to its proper pitch, and it is here that skilled labor is indispensable.

Ladling is usually performed by four men, two loading while the other two are resting.

If the copper contains neither gold nor silver, it is cast into ingots weighing about 16 lbs. The molds are made of copper and are arranged on a shaft fastened to a bosh containing water, so that upon being tipped upside down, the ingot falls out and drops into the water; this is done to give the ingot a red copper color which is due to a thin coating of suboxide.

Should the copper contain gold or silver, it is cast into rectangular plates weighing some 200 lbs., called anodes, which are of convenient size for the electrolytic refinery.

Plate 840



Copper-Refining Furnace

H. L. Bridgman's Design

CUPELLATION

Lead melted with free access of air is oxidized to litharge, while silver and gold, should any be any present, remain unchanged. Advantage is taken of this fact, to separate gold and silver from lead and other base metals, the process being called "cupellation".

The operation is conducted in a reverberatory furnace. The oxidation of the lead is accelerated by a blast of air made to play over its surface, the litharge being allowed to flow off as fast as formed, thus permitting a fresh surface of lead to be continually presented for oxidation. The operation is continued until all the lead has been converted into litharge and removed; the remaining contents of the hearth being a molten mass of refined silver or doré bullion.

The operation may take several hours, fresh bars of argentiferous lead being added from time to time. The silver remaining in the test at the conclusion of the operation may amount to several thousand ounces.

In a lead refinery where there is much lead to be cupelled, the silver-lead bars from the retorts are first concentrated by cupelling off a large percentage of the lead in a large (usually water-jacketed) cupel furnace, called a "concentrator", and the rich silver-lead thus obtained is afterwards completely cupelled in a smaller cupel furnace.

Plate 858 (page 164) shows a welded steel jacket for a concentrator test.

The cupel furnace is sometimes used for extracting silver and gold from lead bullion obtained from the blast furnace, the litharge being afterwards reduced with coke in the blast furnace.

In leaching works where silver is extracted from the ore by sodium hyposulphite and precipitated as sulphide, the best method for refining the sulphide is to cupel it with lead, fine silver bars being the resultant product.

Jewelers' sweepings, rich residues, etc., are usually refined by smelting them with lead and cupelling the base bullion produced.

The English cupelling furnace is the one used for the work herein mentioned.

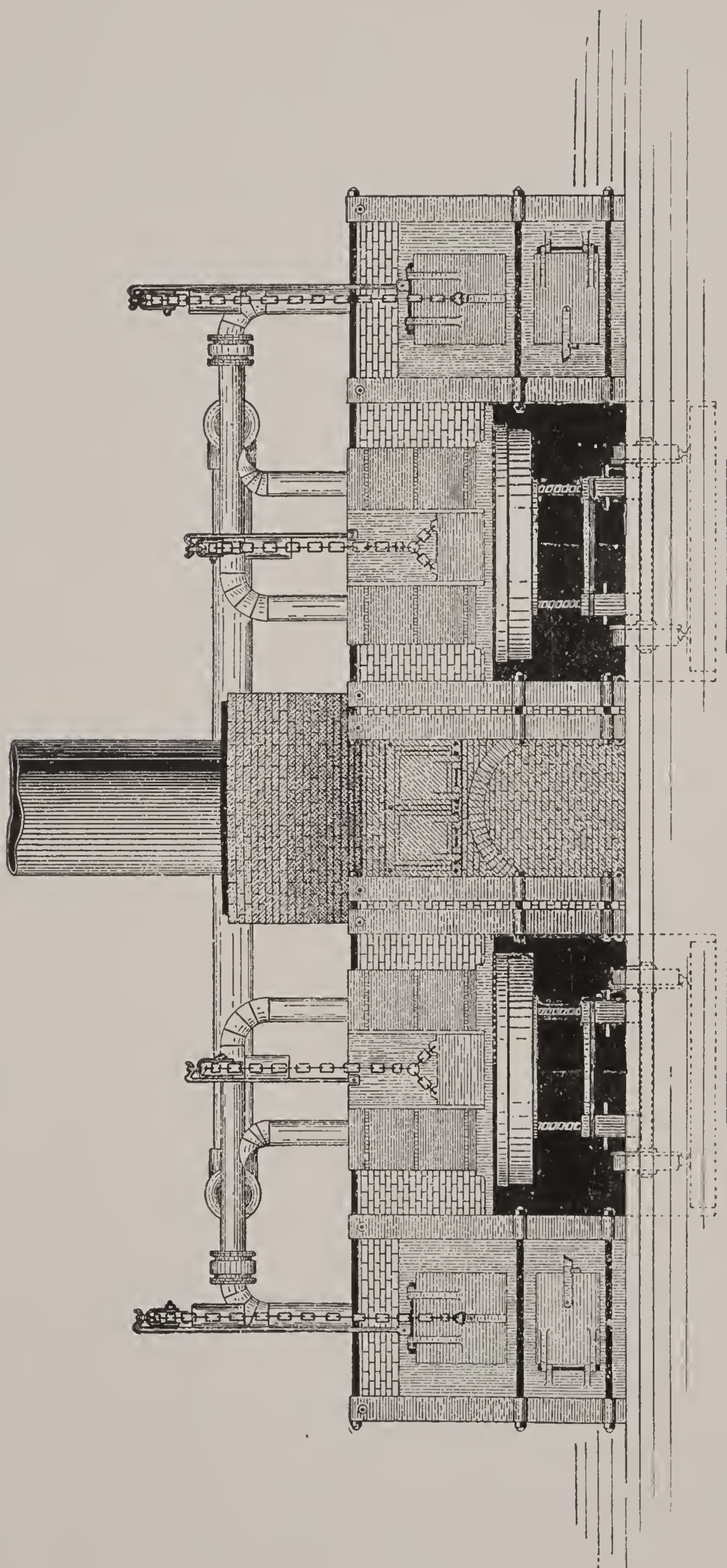
Plate 65 shows our double English cupelling furnace. It consists of a removable reverberatory hearth placed between a fire-box and a flue, all being contained in a brick structure. The hearth comprises an iron frame called a "test bottom", which is filled with a mixture of ground limestone and fire-clay. The test bottom is supported on a car, by means of which it can be readily removed and another bottom substituted in its place. Pipes connected with a fan conduct a blast to the fire-box and to the lead bath.

The outfit for a double English cupelling furnace as furnished by us comprises:

2 Fire and Ashpit Doors and Frames.
2 Litharge Doors and Frames.
2 Charging Doors and Frames.
2 sets of Grate Bars and Bearers.
2 Bottom Plates.
1 double set of Wall Binders and Tie Rods.
2 Litharge Pots and Cars (see Plate 66).
2 Test Cars (see Plate 66).
2 Test Bottoms.
4 extra Test Bottoms.
4 pieces of Track for Test Cars.
4 Tuyere Nozzles (two for cupelling and two for fire blast).
1 double set of Galvanized Iron Blast Pipe, with regulating valves and nozzles for tuyeres, ready for connecting to pipe leading from Blower.

Total weight, 8,300 lbs.

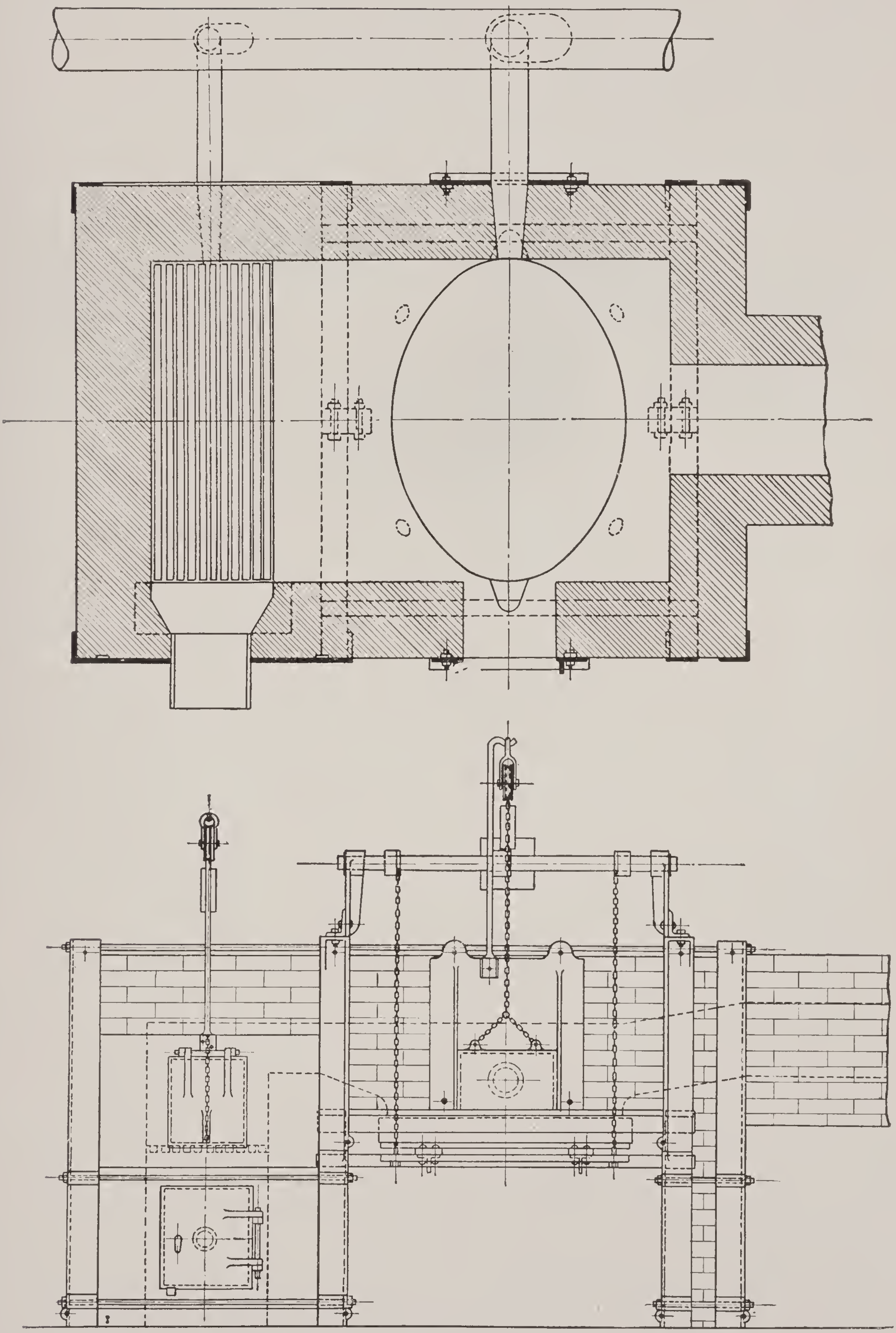
The smokestack is always considered separately, as in many cases the brick stack is preferred.



Double English Cupelling Furnace

Plate 65

Plate 877



English Cupelling Furnace

With Arrangement for Raising or Lowering the Test

Plate 858

WELDED STEEL WATER JACKET FOR A CUPEL TEST

The double furnace requires 16,000 common brick, 2,800 fire-brick and four barrels of fire-clay.

The single furnace requires 9,000 common brick, 1,400 fire-brick, and two barrels of fire-clay.

Plate 877 shows an English cupelling furnace in plan and elevation, with an arrangement for raising and lowering the test, to regulate the flow of litharge without altering the depth of the litharge gutter.

LEAD REFINING

Lead refining or the desilverization of base bullion, is the process of separating the precious metals from lead bars obtained by smelting gold, silver and lead ores. For accomplishing this, the processes of Pattinson and Parkes are available.

The Pattinson process is based upon the fact that if silver-lead bullion is melted and then cooled down to near its fusing point, crystals of lead separate out which are very much poorer in silver than the original lead. If, at this stage, these crystals are removed by a strainer and fresh lead of the same tenor in silver added, the heat increased, the lead stirred and then allowed to cool down as in the first instance, crystals of lead, poor in silver, will again separate out.

By continuing these operations practically all the silver and gold in the bullion will become concentrated in a small quantity of lead which can afterwards be cupelled.

The Pattinson process is not used in the United States.

Parkes' process, universally used in the United States, is based upon the fact that if a very small percentage of metallic zinc is stirred into a bath of molten lead which contains gold and silver, and the lead then allowed to cool down somewhat, the zinc will deprive the lead of the precious metals, forming an alloy which, being less fusible and of lower specific gravity than the lead, will rise to the surface and can be skimmed off and afterwards treated separately for the separation of the gold and silver contents.

The process, which consists of several operations, may be briefly described as follows:

The smelter lead is first put into a reverberatory furnace known as a "softener," where it is subjected for some considerable time at a low heat to the process of liquation, whereby there will arise to the surface dark colored pasty dross, consisting of lead, copper, arsenic and sulphur, which is skimmed off. The slower this operation is performed the more perfect will be the elimination of the copper.

After this stage of the operation has been concluded, the heat is raised and free access of air admitted, whereby complete oxidation of tin, arsenic and antimony takes place, these impurities being also removed by skimming. Of all the impurities in lead bullion, antimony is the most difficult to remove.

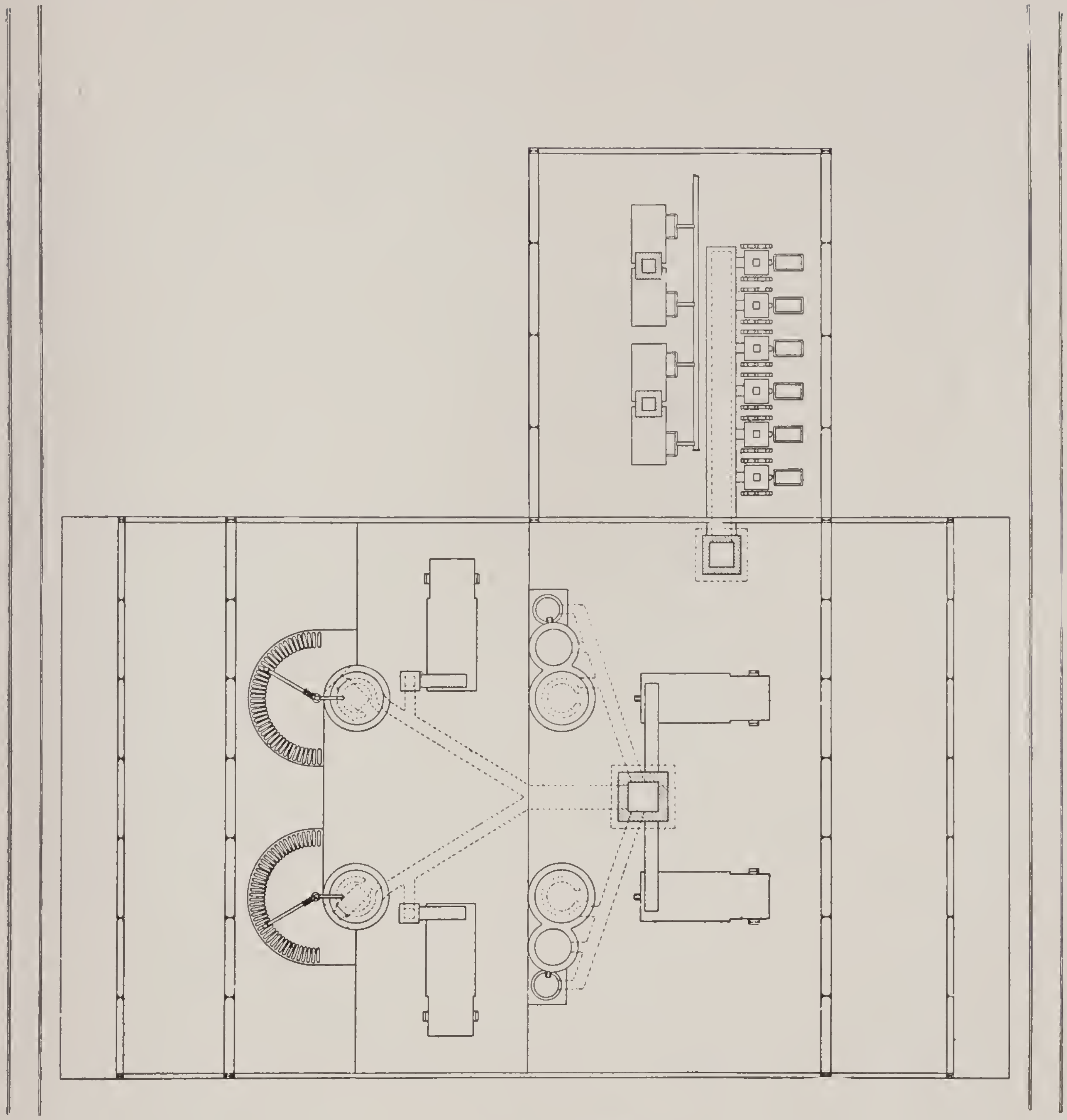
Lead thus purified is ready for the desilverizing kettle; this is a large cast-iron kettle, sometimes holding as much as 60 tons of lead, placed on a brick setting provided with a fire-place. In this kettle usually three "zincings" are made; the first extracts all the copper, all the gold and considerable of the silver (the skimmings being called the "gold crust"), the second (the "silver crust") reduces the silver to some 30 ounces per ton ; the third, usually the last, cleans the lead down to less than 0.2 ounces silver and generally only a trace.

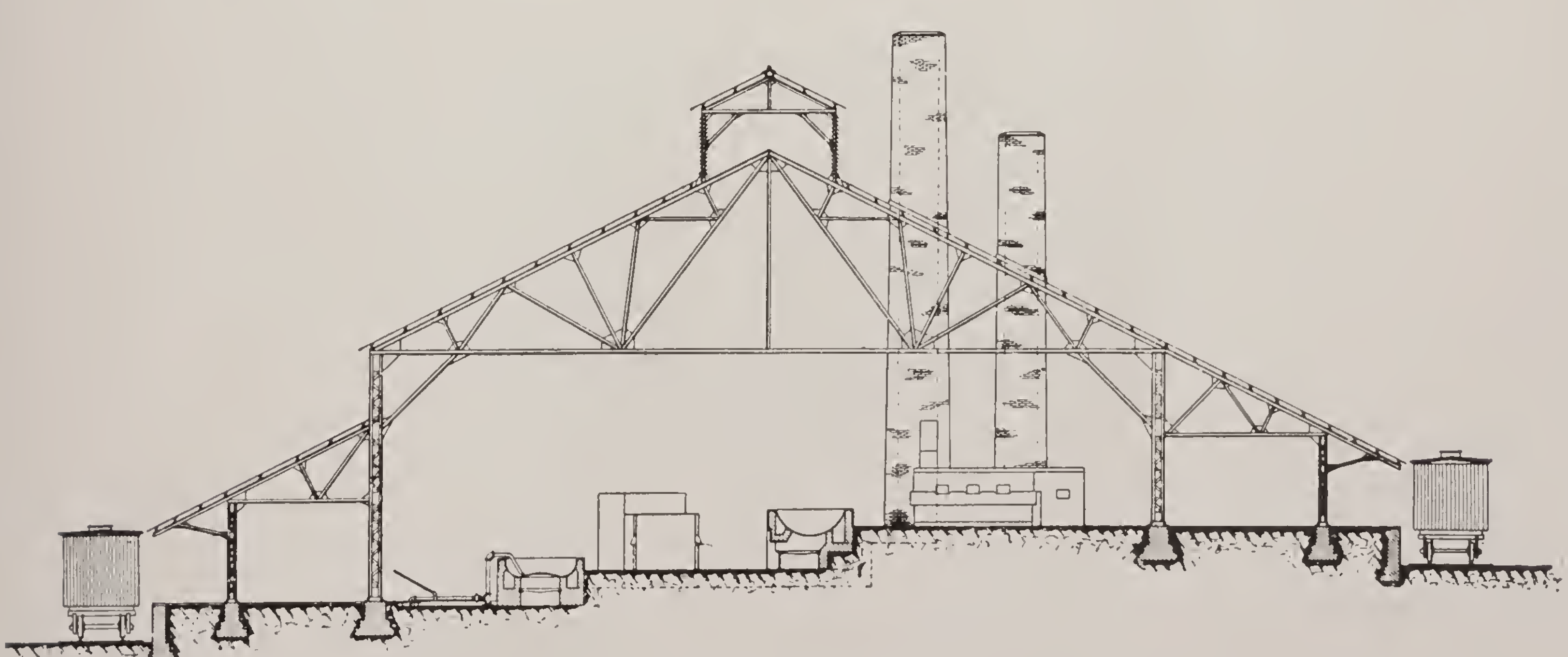
The zinc crusts are next placed in a liquating kettle which is a shallow cast-iron kettle provided with a discharge spout which drains the bottom. The zinc crusts heated in this kettle lose from 50 to 60 per cent. of lead by liquation, this lead running out into a smaller kettle placed on a lower level, leaving the dry zinc crusts behind. This liquated lead, which contains silver and gold, is returned to the desilverizing kettles.

The liquated zinc crusts are next retorted in a bottle-shaped black lead retort, placed in a "Faber du Faur" furnace, each furnace being made to hold one retort. The fuel, which is usually coke, surrounds the retort. By this process, the zinc is distilled off; the greater part recovered in the metallic state is used for "zincing". When no more zinc comes off, the rich lead bullion is poured into molds by tilting the furnace, which is supported on trunnions.

The rich lead is cupelled; the rough bars of fine gold and silver from the cupel are remelted and cast into fine silver or doré bars, the latter being subsequently treated by the electrolytic, or wet methods, for the separation of the gold and silver.

Plate 878





Lead Refinery

The lead in the desilverizing kettles, after having been freed from gold and silver, contains a certain percentage of zinc which must be removed. To effect this separation, it is syphoned into a refining furnace (a reverberatory similar to a "softener"); here under the action of heat and oxidation, the zinc is partly volatilized, partly oxidized and scorified by the litharge, and is removed by skimming.

After tests have shown that the zinc has been eliminated, the lead is tapped into the "merchant" kettle, and from this it is syphoned out into bars, which constitute the pig lead of commerce.

The several by-products of the refinery, the drosses from the softening and refining furnaces, the litharge from cupellation and the blow-powder from the retorts, are all treated by different processes; the constant treatment of by-products goes on simultaneously with the desilverization of the lead bullion.

Plate 878 illustrates the general arrangement of a modern refinery, the details of which will be understood from what we have written. The two softening furnaces will be recognized, also the two groups of desilverizing and liquating kettles, the two refining furnaces, and the merchant kettles with the molds arranged in a semi-circle for casting the lead into merchant pigs. In the smaller room are shown six "Faber du Faur" retorts and two double cupel furnaces.

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